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ORIGINAL ARTICLES.

I.—The Mineral Condition of the Calcium Carbonate in Fossil Shells.

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A RECENT paper by Mr. A. R. Horwood on "Aragonite in the Middle Lias" [1] raises again the question of the condition of the calcium carbonate in fossil shells. Mr. Horwood speaks (p. 176) of Jurassic shells as being "preserved in aragonite", and quotes Dr. Sorby as being of the same opinion. But is Mr. Horwood sure that his shells are still in the aragonite condition? Sorby,[2] when he writes of "aragonite shells", means as a rule shells that were formed of aragonite at the time of the death of the originating animal; but he describes how, in many of our fossiliferous rocks, such shells are represented either by hollow spaces or by pseudomorphs in granular calcite.[3] He points out that oolitic grains, originally consisting of aragonite, have similarly been changed into calcite, the more stable form of calcium carbonate.[4] Some oolitic grains, however, were thought by him to have consisted of calcite from the outset. Doelter,[5] after summing up Linck's researches on calcite and aragonite, states that calcareous oolites now consist of calcite; and we have no doubt that the "recrystallized aragonite concretions", quoted by Mr. Horwood from Sorby, were held by Sorby to be at the time of examination in the calcite state.

Sorby and other workers before 1901 have been compelled to rely upon the test of specific gravity and of relative hardness in distinguishing between calcite and aragonite in shells. A number of interesting observations were brought together in a classic paper by Gustav Rose,[6] who employed the microscope in determining the

[1] Geol. Mag., 1910, p. 173.

[2] Quart. Journ. Geol. Soc., vol. xxxv, Proceedings, pp. 65, 83, 93, etc., 1879.

[3] Ibid., p. 68.

[4] On the relative stability of calcite, see H. W. Foote, "Über die physikalisch-chemischen Beziehungen zwischen Aragonit und Calcit": Zeitschr. für physikalische Chemie, Bd. xxxiii, p. 753, 1900.

[5] *Petrogenesis*, p. 225.

[6] "Über die heteromorphen Zustände der kohlensauren Kalkerde": Abhandl. Akad. d. Wiss., Berlin, 1856, p. 1, and 1858, p. 63. Rose's first researches on the mineral forms of calcium carbonate were published in Poggendorff's *Annalen*, Bd. xlii, p. 353, 1837. A French translation, containing a correction of a slip on p. 361 of the German paper, appeared in the *Annales des Mines*, 1837, p. 611.

mineral nature of many shells. Haidinger[1] observed that aragonite, when heated, flew into fragments, which he believed to be calcite, and Rose showed that these really consisted of calcite, with a specific gravity of 2·709. Rose noticed how under certain conditions of precipitation rhombohedra of calcite were formed, while aragonite was deposited under others, its globular forms changing in time into calcite rhombohedra.[2] It is easy to precipitate aragonite from lime water with ammonium carbonate, and to note under the microscope, as Meigen has done,[3] the gradual assumption of the calcite condition, which involves, of course, a change of volume. The fact that the precipitate consists of aragonite may now be determined by a prompt use of Meigen's solution, to be referred to later. The precipitate must be freed from ammonium carbonate by thorough washing, since this salt gives in a solution of cobalt nitrate a fine violet deposit of cobalt carbonate.

The question with which the present paper is concerned is the rate at which the change from aragonite to calcite takes place in *fossil shells during geological time*. The shell is not free to destroy its intimate structure and to group its molecules in new arrangements unless it can break up entirely into a number of granules of calcite, or unless the excess of calcium carbonate, present in the aragonite state, but not required in the calcite state, can be accommodated somewhere, or removed in solution as the change goes on.

Aragonite with a specific gravity of 2·94 expands 8·088 per cent. in turning into calcite with a specific gravity of 2·72. Such an expansion is comparable in amount with that which accompanies the formation of ice from water; and it is quite possible that ordinary pressures in sedimentary rocks are sufficient to restrain it. In any case, where the change of mineral condition takes place in a fossil shell without alteration of its bulk and form, it seems likely that solution has been at work. It may be urged that the organic matter occupies considerable space in the living shell, and that the hollows left by its decay are sufficient to accommodate the molecules of calcium carbonate when re-arranged in the calcite state. But this would not apply to the numerous cases of the conversion of oolitic grains from aragonite to calcite, and here removal of material by solution seems the only explanation.

It should be remarked that Rose[4] found that microscopic crystals of aragonite, which he obtained by evaporation of a solution of calcium carbonate in water containing carbon dioxide, retained their form even after heating, although their specific gravity of 2·700 showed that they had passed into the calcite state. Rose described them as true pseudomorphs, in which an expansion and re-arrangement of the particles had taken place. But such an expansion of every oolitic grain and shell-fragment in an oolitic limestone seems improbable.

[1] "Ueber die Veränderungen, welche gewisse Mineralien, etc.": Poggendorff's *Annalen*, Bd. xi, p. 177, 1827; also Trans. Roy. Soc. Edin., 1827.

[2] Op. cit., 1856, p. 1.

[3] "Beiträge zur Kenntnis des kohlensauren Kalkes"; Ber. naturforsch. Gesell. Freiburg i. Br., Bd. xv, p. 1, 1907.

[4] Poggendorff's *Annalen*, Bd. xlii, p. 363, 1837.

In determining the specific gravity of modern shells, the organic matter presents a difficulty, as was, of course, recognized by Sorby.[1] Sorby estimated the specific gravity of this matter as 1·5, and obtained its proportion by weight by carefully burning it off, and restoring, by treatment of the residue with a solution of ammonium carbonate, any carbon dioxide that might have been lost. The specific gravity of the shell in its original condition, the masses of its two constituents, and the density (1·5) of one of them are known; the density of the other, the calcium carbonate, can then be calculated.

Professor W. J. Sollas[2] shows that 12·5 per cent. of organic matter will reduce the specific gravity of a shell from 2·9 to 2·725, while 14·37 per cent. will bring it to 2·7, a value commonly afforded.

When Professor E. H. L. Schwarz[3] argued in 1894 that the shell of the modern *Nautilus* consisted of calcite, since its specific gravity was 2·68, he may have been misled by the presence of organic matter. As soon as his paper was published, one of us obtained a similar result for *Nautilus* (2·70), while the shell of *Spirula* was found to have a density lower than 2·60. The organic jelly obtained on dissolving the latter shell was, however, very conspicuous. It seems possible that the value obtainable may vary in modern shells according to the conditions to which they have been subjected, and that long exposure to sunlight and the attack of organisms on a tropical beach may reduce them to the state of fossil shells. It is clear, however, that organic matter may remain present for a long time, since bleached shells of *Mya* gathered from a raised beach in Green Bay, Spitsbergen, yield a considerable amount of jelly on solution.

Professor Schwarz proceeded to argue that the shells of ammonites, which are often missing, and which are commonly formed of calcite when preserved, originally consisted of calcite, like their aptychi. Sorby, however, had already stated the specific gravity of the shell of *Nautilus* as 2·95,[4] and had suggested the presence of a little calcium phosphate in addition to aragonite. The internal shell of *Sepia* yielded him 2·91. Hence the ammonites also have been generally held to have had shells of aragonite, which have passed gradually into calcite.

Using Sollas's diffusion column and methylene iodide, one of us made the following determinations on fossil shells in 1894, calcite and aragonite being the floating indices in the liquid:—

Nautilus, Gault, Folkestone. 2·73. Calcite.

Calonautilus carinatus, Carboniferous Limestone, County Limerick. 2·68. Calcite.

Cosmoceras Jason, Oxford Clay, Chippenham. 2·675. Calcite.

Harpoceras Brighti, Oxford Clay, Christian Malford. Would not sink until powdered, probably through air-cavities. The powder

[1] Quart. Journ. Geol. Soc., vol. xxxv, Proceedings, p. 59. See also Rose, *Abhandl. Akad. Wiss.*, Berlin, 1858, p. 68.

[2] "On the Physical Characters of Calcareous and Siliceous Sponge-spicules and other Structures": Sci. Proc. R. Dublin Soc., vol. iv, p. 390, 1885.

[3] "The Aptychus": Geol. Mag., 1894, p. 457.

[4] Op. cit., p. 60. Cf. Cornish & Kendall, "On the Mineralogical Constitution of Calcareous Organisms": Geol. Mag., 1888, p. 71.

mostly yielded 2·755, but ranged from 2·58 to 2·79. Possibly some aragonite or dolomite.

Hoplites lautus, Gault, Folkestone. Two separate specimens, 2·75 and 2·79. Probably some iron pyrites present.

Hamites intermedius, Gault, Folkestone. 2·71. Calcite.

Aptychus, Kimmeridge Clay, Ely. 2·688. Calcite.

Belemnites giganteus, guard, Lias. 2·677. Calcite.

Psiloceras planorbis, Lower Lias, Watchet. Six pieces from one specimen gave respectively 2·88, 2·88, 2·93, 2·94, 2·97, and 2·97. One of the pieces giving 2·88 was then powdered; the bulk of the powder floated at a level indicating 2·80. The powder ranged, however, from 2·65 to 2·98. Internal mineral differences here probably interfere with a true result, but the indication of aragonite is remarkable.

This last result gave cause for thought. Can aragonite be retained in the shells of ancient deposits, and under what conditions? Rose [1] has recorded aragonite crystals on the walls of the fibres of *Inoceramus Cuvieri* from the Plänermergel of Strehlen; but it does not appear that he traced shells consisting of aragonite into deposits of any antiquity. Tschermak [2] remarks that the proportion of aragonite decreases in older shells, although this mineral is found in fossil shells. No further observations, however, are recorded by him on this point. Messrs. Cornish & Kendall [3] deal mainly with the solution of aragonite shells, rather than with their replacement by calcite. It is not clear that Sorby [4] meant to assert that certain Gastropod shells in the Barton Clay remained in the aragonite state. He calls attention to the preservation of their structure, but is inclined to suggest partial silicification to account for it. As already stated, his use of the phrase "aragonite shells" seems by no means to imply shells *now* consisting of aragonite.

It seemed to us important, then, to see how far "aragonite shells" can remain as aragonite in geological time. We have always to remember in such an investigation that, when we meet with a fossil shell of high specific gravity, there is the possibility of partial phosphatization. This difficulty was indicated by Sorby, but has been removed in recent years by the ingenious test devised by Herr Meigen [5] to distinguish calcite from aragonite. Powdered aragonite, as is now well known, turns lilac after boiling in a solution of cobalt nitrate; while calcite, unless extremely finely powdered, gives no reaction.

The standard solution used in the following experiments was prepared by adding two volumes of water to one volume of a cold saturated aqueous solution of cobalt nitrate. The time of boiling in

[1] "Über die heteromorphen Zustände der kohlensauren Kalkerde": Abhandl. Akad. d. Wiss., Berlin, 1858, p. 80.

[2] *Mineralogie*, 1884, p. 418.

[3] "On the Dissolution of Aragonite Shells in the Coralline Crag," GEOL. MAG., 1883, p. 497; and "On the Mineralogical Constitution of Calcareous Organisms", ibid., 1888, p. 68.

[4] Op. cit., p. 77.

[5] *Centralblatt für Min.*, etc., 1901, p. 577, and *Ber. naturforsch. Gesell. Freiburg i. Br.*, Bd. xv, p. 20, 1907.

each case was three minutes. The first materials tested, to establish a standard method, were powdered calcite and aragonite.

Chemically prepared tricalcic orthophosphate gives a fine violet reaction, and this has led one of us into the error of stating that apatite "gives a blue precipitate".[1] Several varieties of apatite and phosphatized fossils tested by us are, as a matter of fact, found to give no reaction, and this clears the way as regards the occurrence of calcium phosphate in shells the specific gravity of which resembles that of aragonite.

Since Meigen mentions only results with artificially prepared strontium and barium carbonates, it may be useful to state that we find that two specimens of strontianite, one from the Harz and one from Westphalia, give a *blue* reaction, while witherite turns violet like aragonite. Magnesites from Haute Vienne and Silesia and siderite from Cornwall give no reaction.

Seeing how colour-changes occur unexpectedly in certain reactions, we tested pyrite, marcasite, and a number of pyritized fossils, but without result. We may conclude, then, that the violet reaction on which we rely in our observations is a true indication of aragonite. The presence of witherite is too improbable to vitiate the argument.

Among RECENT specimens we tested *Nautilus pompilius* and *Arca Noæ*; both show the aragonite reaction. *Tubipora* retains its red tint, but gives no indication of aragonite.

PLIOCENE. Professor Kendall[2] showed that aragonite shells may be removed altogether in solution from the permeable Coralline Crag. Those that remain are not likely to have been converted into calcite. The following were tested and consist of aragonite. Chillesford Beds: *Mya arenaria*. Red Crag: *Cardium Parkinsoni*.

MIOCENE. Burdigalian: Leognan, *Arca Girondica* and *Turritella terebralis* are both aragonite.

OLIGOCENE. Aquitanian: Mérignac, *Arca cardiiformis*, aragonite.

EOCENE. The "aragonite shells" sometimes show friability and indications of partial solution, but they seem able to hold their own in a remarkable degree against transformation into the calcite state. The following were tested, and all seem to be in their original mineral condition. The one calcite shell in the series is *Ostrea submissa*, from the Yprèsian of Cuise-la-Motte; but, as is well known, the oysters form their shells of calcite. All the following are aragonite. Bartonian: Haravilliers, France, *Arca biangula*. Lutetian: Chaumont-en-Vexin, *Eupsammia trochiformis*; Bracklesham, *Litharœa Websteri* and *Arca duplicata*; Chaumont-en-Vexin, *Cardium porulosum* and *Turritella carinifera*. London Clay: London, *Nautilus regalis*. Lower London Tertiaries (Thanetian): Chislehurst, *Cyrena cuneiformis*.

CRETACEOUS. Gustav Rose[3] found crystals of aragonite on the fibres of *Inoceramus Cuvieri* from the Plänermergel of Strehlen. Messrs. Cornish & Kendall[4] determined that *Parasmilia centralis* from the

[1] *Aids in Practical Geology*, 6th ed., p. 36.
[2] GEOL. MAG., 1883, p. 497.
[3] *Abhandl. Akad. Wiss.*, Berlin, 1858, p. 80.
[4] Op. cit., GEOL. MAG., 1888, p. 72.

Upper Chalk is calcite, with a specific gravity of 2·70. We have verified this with Meigen's solution, and regret that it is difficult to find other suitable fossils for comparison. *Spondylus*, for instance, possesses an outer calcite layer, while *Ostrea* and *Pecten*, both common in the Chalk, form calcite shells. The Cephalopods, other than *Belemnites*, from the Chalk are usually in the form of casts, and there is a general dearth of material that might have been aragonite at its time of deposition. From the Upper Greensand of Devizes, however, we have a specimen of *Arca carinata*, which has the decayed and crumbly look of an old aragonite shell; and this proves to be actually aragonite.

When we come to the Albian horizons, we possess numerous fossils from the Gault Clay which have remained in the aragonite condition. The following are all aragonite: Folkestone, *Cyclocyathus Fittoni*, *Alaria carinata*, *Hoplites tuberculatus*, *Hoplites splendens* (two specimens); Mid-Surrey, *Nucula pectinata* (showing a characteristic powdery appearance). On the other hand, the following from the Gault of Folkestone have passed into calcite: *Solarium ornatum*, *Nautilus*, *Hoplites lautus*, *Hamites elegans*. A *Solarium* again, from an unrecorded Gault locality, has remained as aragonite.

It is clear that local conditions have allowed a majority of Gault shells to remain unaltered, while others have undergone change in geological time. We may expect to find this change emphasized in Jurassic strata.

Jurassic. Coral Rag: West of England, *Thecosmilia annularis*, *Thamnastræa arachnoides*; both calcite. Kelloways Rock: Christian Malford, *Cosmoceras Elizabethæ*, calcite. Bath Oolite: Minchinhampton, *Arca hirsoniensis*, *Arca Prattii*, *Arca minuta*; all calcite. Inferior Oolite: *Parkinsonia Parkinsoni*, calcite. Middle Lias: Cheltenham, *Macrodon Buckmani*; Lyme Regis, *Ægoceras Henleyi*; both calcite. Mickleton, *Ægoceras capricornus*, aragonite. Lower Lias: Robin Hood's Bay, *Psiloceras planorbis*, calcite; Watchet, *Psiloceras planorbis*, aragonite.

The interest here is concentrated on two ammonites. The *Ægoceras* from Mickleton is very well preserved in a slightly argillaceous limestone, while the *Psiloceras* from Robin Hood's Bay is also in a clayey limestone. That from Watchet is in a shale; it was this specimen that raised the question of the retention of aragonite in ancient strata, when its specific gravity was found, in 1894, to be as high as 2·9. We have examined Jurassic *Arcas* specially as a type, and it is clear that there is a very general tendency for "aragonite shells" of this period, when they survive at all, to be preserved as calcite.

Trias. Red marine strata of Han Bulog, Bosnia, *Ptychites striatoplicatus*, calcite.

Carboniferous. Carboniferous Limestone, *Cœlonautilus carinatus*, calcite. Shale, Cuilcagh, *Orthoceras*, calcite.

Finally, we have verified Sorby's observations on Oolitic limestones, with the foreseen result that, while the oolitic grains from the modern Great Salt Lake of Utah consist of aragonite, those of Jurassic age from Portland, Leckhampton, and Dalberg in Hanover have passed into calcite.

It is obvious that a research of this nature may be indefinitely extended; but enough has been here set down to show that Mr. Horwood may be justified in expecting some retention of aragonite even in Jurassic strata. The change into calcite in stratified deposits is really very slow. Aragonite shells are often affected by solution in Cainozoic strata, but not ordinarily by conversion into calcite. A study of compact Eocene limestones may be expected to show calcite pseudomorphs, at any rate in some parts of the world; but European clays and sands alike seem to allow of the retention of the aragonite state, until we reach well back into the Cretaceous period.

In the Gault of Folkestone we have a tendency for the development of calcite. It would be interesting to know if this occurs in certain zones, where percolation of water happens to be more free. Certainly the evidence of Jurassic limestones is strongly in favour of the general change of aragonite into calcite in beds of this age, though aragonite may exceptionally be preserved in certain argillaceous strata. We can now hardly expect to find aragonite in shells older than the Jurassic period.

Sorby[1] held that aragonite shells often broke down into "fine-grained calcite mud", and were thus lost sight of in limestones. Rapid accumulation might, he thought, have saved them in some Jurassic limestones; but even then it is not clear that he regarded the shells and corals thus preserved as still consisting of aragonite. We ourselves find no evidence of the disappearance of aragonite shells by granulization. Unless actually dissolved, they may remain as aragonite, with their original forms and structures, though they have come down to us from the opening of Cainozoic times.

In view of the instability of aragonite as precipitated in certain chemical experiments, it is interesting to find that the same substance, when organically deposited, holds its own so well through a long series of geological periods.

II.—The 'Dragon-tree' of the Kentish Rag, with Remarks on the Treatment of Imperfectly Petrified Woods.

By M. C. Stopes, D.Sc., Ph.D., F.L.S., Lecturer in Fossil Botany, Manchester University.

In the early numbers of the Geological Magazine the 'Dragon-tree' received considerable attention. It was thought to be a Monocotyledon and described as a species of *Dracæna* by Mackie in 1862 (*Geologist*, p. 401, pl. xxii). The specimen appears to have attracted an unusual amount of interest prior to 1870, and it is referred to by Mantell and other contemporary writers. Carruthers placed it among the British fossil Pandanaceæ in 1868 (Geol. Mag., p. 154). Like other specimens from the sandstones of the Iguanodon Quarry (Lower Greensand of Maidstone), no internal structure appeared to be preserved, and the determination of its nature rested entirely on the external features.

[1] Quart. Journ. Geol. Soc., 1879, Proceedings, p. 83.

In his Wealden Catalogue Seward points out that there is nothing in this fossil to indicate that it had an Angiospermic affinity, and in 1896,[1] in a review of the supposed fossil Angiospermes, he amplifies this and gives the plant the non-committal name of *Benstedtia*. This genus he places among the Cycads, illustrating the likeness between the markings on the outside of the fossil and those on the living species of *Zamia Skinneri*. This superficial similarity is very close, and is well illustrated in his pl. xiv. The particular point on which stress is laid in the comparison is the presence of irregular transverse ridges and grooves, instead of the usual armour-plate of leaf-bases common in Cycads.

Since the Maidstone Benstedtias have been described a few specimens have been found elsewhere. Among the fossils of the Uitenhage Series of South Africa are some which are put by Professor Seward in the genus *Benstedtia*. In this paper[2] Professor Seward remarks that the casts called *Coniferocaulon colymbeæforme* by Fliche appear to be identical with *Benstedtia*. These casts, like our specimens, show no internal structure whatever.

As Professor Seward remarks (loc. cit., p. 217), since none of the wood structure is retained in the fossils conclusive evidence as to their nature is not to be looked for. He notices the wood-like appearance towards the middle of the largest of the specimens, but observes that it is of purely mineral nature.

One of the objects of the present paper is to record the fact that I have found true wood remains in these fossils. In the course of my work on Cretaceous plants I have had occasion to re-examine the figured specimens, and have one or two further observations to offer concerning their botanical affinities.

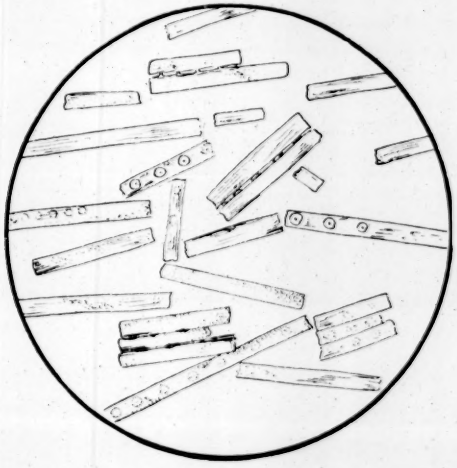
In the British Museum there are more specimens than have been mentioned by previous writers. One of these lends support to the doubt I feel that in the casts of *Benstedtia* described by Professor Seward and others we are really dealing with the external features of the plant. The likeness of the external appearance of these casts to those of the true exterior of *Zamia Skinneri* is without doubt; but if in the fossil we are not dealing with true external features the comparison ceases to be of any value. No. V. 9572 in the British Museum shows two layers of this supposed exterior superimposed for a short distance, and with nearly a centimetre of matrix between them. This evidence is, of course, not conclusive, but it suggests that the 'exterior' represents zones of cortex or bark at various levels in the decorticated stem.

Close examination of the largest specimen (No. 8357), to which all previous English writers have referred, revealed that there *is* a remnant of true wood in the axis of the cast. The crystalline matter simulating wood, mentioned by Professor Seward in his account of this specimen, is clearly to be recognized, and is distinct from the true remains of woody tissue.

[1] *Annals of Botany*, vol. x, pp. 216 et seq., 1896.

[2] "Fossil Floras of Cape Colony": Ann. S. African Mus., vol. iv, 1903, see pp. 34–6.

Previous work on extremely ill-preserved woods in greensand matrices had prepared me to deal with wood in the condition of a white, semi-silicified, fibrous mass, which crumbles to the touch. As such remains are the only form which vegetable fossils take in some deposits, it may be of value to note the simple point of technique which I have found useful. With such specimens collodium casts are not obtainable, as the collodium sinks into the fibrous surface and does not form a proper film. Ordinary sections are out of the question; examination with a hand lens gives one no clue to the nature of the wood, because it is generally so incompletely preserved as not to show even its annual rings. I have found, however, that if one selects a portion of the wood remains free from matrix, the point of a sharp pen-knife will free with the lightest touch some of the fibrous powder of the wood. If this powder is then mounted on an ordinary slide, soaked in water for a short time under a cover-glass, it will be found that it consists of short lengths of individual tracheids, generally separate from each other or lying in pairs.



Some of the powder from the pulverizing wood, as seen under the microscope, showing the separate lengths of the tracheids, some of which show bordered pits.

Many of these tracheids show no markings, but in most woods that I have examined, however poor they may be, at least a few of the tracheids show their characteristic pittings. In this way I have recognized in minute scraps of pulverizing wood true Abietineous pitting, with round bordered pits in single rows, and other woods with *Brachyphyllum*-like pits in irregular pairs. The sharpness of the border in these bordered pits (which show sometimes the small central opening also) is remarkable, considering the unpromising nature of the material. In a few cases short lengths of medullary rays accompany the tracheids, but in general one does not get more than the tracheal markings to work upon. These, however, are sufficient to determine the main group to which the plant belongs.

When, therefore, I found traces of pulverizing woody remains in *Benstedtia* I examined them critically, and by this simple method was able to determine that the wood of *Benstedtia* was gymnospermic, and that the tracheids had circular bordered pits, lying in a single row at some distance from each other. These are quite unlike the Cycads, which have several rows of closely adjacent pits. Although this does not make it possible to determine the exact genus to which *Benstedtia* must have belonged, it yet proves without doubt that the plant was one of the higher Coniferæ, probably of the Taxodineæ or Abietineæ: the Araucarineæ, Taxaceæ, and Cycads are eliminated from the plants available for comparison.

Fliche, Bull. Soc. Sci., Nancy, 1900, pp. 15 et seq. (I am indebted to Professor Seward for reminding me of this paper), compares casts of French specimens which have surface features like *Benstedtia* (with which, however, he does not compare them) with the living Araucarias, and in particular with the section Colymbea. In the absence of internal structure in his specimens this comparison may still hold good, for there is nothing to show that his plant was not an Araucarian type. As in the similar British specimens, however, the wood is that of the higher Coniferæ, it may probably appear later that the French specimens belong to this group also. This is further supported by one of our fossils, which practically proves that the transversely ridged 'exterior' is not necessarily the true outer surface of the plant as it was when alive. Fliche assumed that his transversely ridged stem was directly comparable to the Araucarinene he mentions.

It has not been easy to find among living Coniferæ a parallel development to the curious transverse ridging which is conspicuous in some of the specimens of the fossil, and which is so like the *Zamia* figured by Professor Seward. In most of the specimens available there seemed no possible stage of decortication that would give a parallel to the features in the fossil. In some of the very contorted and warped specimens of trunks which are common enough in plants grown under unfavourable circumstances, I found that the wood splits down so as to give a rippling, transversely ridged surface, very similar to the fossil. Also trunks with such warped and contorted woods simulate the apparently dichotomizing trunk figured by both Mackie and Seward.

The curious little rounded protuberances in these ridges in some specimens figured by previous observers and taken by Professor Seward to be a feature of the plant itself are not present in all the specimens, and appear to me to be possible of interpretation as the ends of teredo borings, left, not as true borings, but as impressions of borings in the cast of the ripple-surfaced wood. Such wood, splitting longitudinally so as to give a rippled surface, can be seen at Kew in the collection of conifer woods, and, as teredo borings of the diameter of the protuberances in the fossil are not at all uncommon for this geological horizon, this explanation of the whole structure, though dull and prosaic, has the merit of probability and simplicity. The hollow stem which some have attributed to the plant is without doubt due to decay preceding petrifaction.

Except for historical interest, and for the convenience of having

a name by which to designate a special kind of cast of a genus known otherwise (compare the *Knorria*, etc., of *Lepidodendron*), there appears no reason now to give *Benstedtia* a generic name of its own. In describing the African plants Professor Seward retained the name *Benstedtia*, for, as he said (1903, p. 35), "without anatomical evidence . . . a non-committal term such as *Benstedtia* is preferable" to the specific name given to similar things by Fliche, which attributes to them distinct affinities. As, however, we have now direct evidence in the details of the wood tracheids that our British specimens belong to the Coniferæ, but are not Araucarian, it seems best to include them in the genus *Coniferocaulon* of Fliche and retain König's original specific name *Benstedii*. Fliche's specimens, although very probably really belonging to the same true species, may be left under Fliche's specific name till his view as to their nature is proved or disproved by evidence of internal structure. Our plant, then, the *Dracæna Benstedii* of König, the *Benstedtia* sp. of Seward, is best designated by the name *Coniferocaulon Benstedii*, and placed among the higher Coniferæ.

Though the 'Dragon-tree' was a much more romantic figure before its ordinary gymnospermic features were revealed, consolation for this loss may perhaps be afforded by the fact that it illustrates the use that even pulverizing fossil wood may be in determining affinities of doubtful plants, when handled with a method so technically simple as that described above.

III.—Fissureless Volcanoes.

By Dr. Hans Reck.

AS I could not give in this paper anything like a full account of my observations and the results of my studies concerning this question made during an expedition through Iceland in the summer of 1908, I must refer the reader to my special papers on this subject.[1] Everyone will find there the reasons which have induced me first to suppose the independence of the so-called 'Schild' volcanoes in Iceland of pre-existing fissures. This idea is confirmed by collecting proof after proof on the subject in the field during my researches. Naturally I could not give all the details in a first short preliminary communication, a fact which, I am sorry to say, has caused Professor Schwarz to doubt the correctness of part of my observations and conclusions. I may therefore be allowed to discuss shortly the two main objections of Professor Schwarz to my theory.[2]

Briefly summarized, the facts are as follows: Out of the level highlands of Central Iceland a few block-like, square-formed, flat-topped

[1] Hans Reck, "Ein Beitrag zur Spaltenfrage der Vulkane": Centralbl. f. Min., Geol., u. Palaeont., 1910, No. 6, pp. 166–9, 1 fig. "Ueber Erhebungskratere": A. d. Monatsberichten d. Deutschen Geol. Ges., Bd. lxii, No. 4, pp. 295–319, 9 figs., 1910. "Isländische Masseneruptionen": Kokens geol.-palaeontolog. Abhandlungen, Heft ii (Bd. ix der neuen Folge), pp. 80–186, 9 plates, 1910. "Das vulkanische Horstgebirge Dyngjufjöll mit den Einbruchskalderen der Askja und des Knebelsees sowie dem Rudloffkrater in Zentral-island": Abhandlungen der Königl. Preuss. Akademie der Wissenschaften vom Jahre 1910, pp. 1–100, 8 plates.

[2] See Geol. Mag., September, 1910, p. 392.

mountains rise abruptly from the plain at their feet to a height of 1,000 to 1,200 metres. Their summit plateau consists of lava gently rising from all sides to the crater. All the mountains in question show exactly the same lines and details of structure, so that it may be just as well here to confine myself to the description of Herdubreid only as a type for all the others. The summit plateau ends abruptly on all four sides with vertical walls which show a clear and fresh section of the mountain structure, as all the detritus is constantly being removed by the wind, and no vegetation hides even the finest details of the composing rocks. Only the lowest part of Herdubreid up to the height of a few hundred metres is hidden by huge accumulations of debris.

Beneath the lavas of the upper region follows the main bulk of the mountain, consisting of palagonite tuff. Here it is that one would expect to find a fissure if such existed. It must be stated that all the four mountain walls are practically vertical, uninterrupted, even, and stand at right angles to one another. Two of these lie in the general N.–S. line of all the tectonic and volcanic lines of fissure eruptions in the north of Iceland, but all these faults are of more recent date than the volcano, as parts of it are disturbed by their dislocations. Older faults are up to now not yet known in the surroundings of Herdubreid.

In the palagonite tuff of the north side of Herdubreid, where we ought first of all to expect to find a volcanic fissure, an horizontal line is to be seen separating a brighter- from a darker-coloured part of the tuff. The uninterrupted course of that line all along the wall absolutely proves that there is at least no line of *dislocation* on which the volcano could have appeared. Furthermore, the absolutely uniform structure of the tuff, not only here but on all sides, seemed to me proof enough that there was not only no dislocation but just as little a line of weakness or a fissure. A fissure open at the time of the first outbreak of the volcano and no longer open to-day must have been closed since, either by filling up with lava from below or with detritus from above, or, as Professor Schwarz seems to believe, by tectonic movements which, without dislocations, would have pressed together the edges of the fissure.

The first objection of Professor Schwarz is, that a fissure might exist in the palagonite, but be healed and thus made invisible to the eye. For this he adduces a most instructive example from the Berg River, Hoek, near Paal, in Cape Colony. He has stated that there a great fracture was healed, and the rock brecciated and hardened to a distance of 3 to 4 yards on both sides. Supposing now such a fracture with brecciated and hardened sides would run through the even, vertical, fresh wall of Herdubreid. In the quick process of decomposition of the soft palagonite tuff such a hardened zone of brecciated material would necessarily manifest its character by standing out from the wall as a dyke. On the other hand, it would naturally have to appear as a ravine if the rock along the fault was only brecciated and thus loosened in its structure but not hardened afterwards. But neither the least signs of brecciation nor of unevenness in the perpendicular mountain side could be observed.

Similarly a fissure filled from below with lava or from above with debris would always be distinguishable by the necessarily different structure of the in-filling material compared with the uniform composition of its surroundings, so that after all I can only repeat my first statement: It is therefore here for the first time proved from observation that in this case at least a fissure does not exist under the base of a volcano for a depth of from 300 to 400 metres.

Professor Schwarz's second theoretical objection is, that, granted there were no line of weakness in the palagonite itself, one might better regard the volcano as the offshoot of a deeper-lying volcanic fissure than to admit it having been formed by piercing its own way up through the earth's crust even from the magma basin whence it derived its lavas.

There are several reasons which, unfortunately, do not allow me to agree with Professor Schwarz's ideas. First of all I must repeat that there is no fault known in the whole volcanic surroundings of Herdubreid that is proved or even likely *to be older* than the volcanic activity of the mountain which began after the ice of the last glaciation had long been melted away.[1] At any rate the fractures and dislocations by which the surroundings of Herdubreid sank down for at least 600–700 metres, and left it as a huge mountain block in its old position, are younger than the volcano, for they have dislocated even the youngest outpours from its crater.

The reason that allowed Herdubreid to keep its old position can only be found in its being a 'Schild', or massive lava volcano, with an axis of solid lava under its central parts, which served as a strong support against the sinking movements of the surrounding crust.

The volcanic axis piercing the base of the volcano in no place touches the vertical walls of the volcanic 'Horst', so that from this fact it is only probable that the chimney would go down rather perpendicularly, which is also theoretically necessary to assume from reasons which I have given in the above-mentioned papers, and which are based on the symmetry of the shape of the volcano. So that, even if we were inclined to assume an old fissure under the lava-covered surface of the surrounding level plain, the offshoot of the volcano would necessarily have taken place very deep below the surface.

But why at such a depth should the rising magma suddenly have left the line of weakness which would have led its lavas in the easiest and shortest way up to eruption? I think it will be rather difficult to find sufficient reasons for even a theoretical explanation of this, but there is one more point which seems strongly to negative the assumption of an underground fracture as the conduit for the magma.

Professor Schwarz assumes Herdubreid to be an offshoot of a volcanic fissure, and adduces as example for the possibility of his opinion Daubrée's well-known experiments on the exploding of dynamite in steel shells. He also gives a very interesting example of a "fossil earthquake", as he has termed it, which in its course showed characters of a similar kind. In his latter example single blocks,

[1] Compare also Helgi Pjeturss, *Zeitschrift der Gesellschaft f. Erdkunde*, 1908, pp. 451 ff.

torn off from below, have drilled cylindrical holes into the overlying Karroo shales.

Now one cannot possibly imagine Herdubreid with a circumference of, let me say, about 14 km., measured along the vertical walls, to be a block torn off and shot up from the underlying ground. Not even a slow upward movement can explain all the facts to be observed, as I have shown in a previous paper. The great bulk of the mountain in a similar way makes it very difficult for me to imagine it as something like a parasitic cone in comparison with a great volcano. For where is the great volcano or the grand volcanic fissure of which Herdubreid should be a parasite? Neither of them is at present known in Iceland.

If we compare Professor Schwarz's hypothesis of Herdubreid as an offshoot of some unknown volcanic fissure, and Daubrée's experiments, with the facts observed in nature, we are confronted at once with the question: Do all the leading features really coincide in nature and in the experiment? In Professor Schwarz's theory as well as in Daubrée's experiments gases are the moving factor of the eruption, and their prevailing action is the necessary proposition to the experiment, as it depends mainly on their explosive force. Do we find anything like that in the case of Herdubreid? Observation gives not the least support to the assumption of any explosions worth mentioning, neither in the beginning of the first eruption nor during the course of later ones.

By climbing up the steep cliffs of palagonite and lava in ascending the top of Herdubreid for the first time I actually passed over the entire section across the mountain, and had to climb from sheet to sheet of the basaltic lava-flows of the upper region. But neither at the base of the lowest one nor as accumulations between later outflows could I find loose volcanic material such as ashes, lapilli, bombs, pumice, or broken pieces of the ground, which are the most evident companions of all volcanic explosions. On the contrary, the want or but feeble display of explosions is one of the most characteristic peculiarities of the 'Massenеruptionen', of fissure eruptions as well as of the eruptions from central craters in the case of lava volcanoes. No 'Schild' volcano is known in Iceland to have erupted in historic times, but all the characteristics of the crater and its surroundings point to a mechanism of eruption just as we can observe it in the huge lava volcanoes of Hawaii, Kilauea, and Mauna-Loa, where in historic times all the eruptions but one have taken place without the development of any remarkable explosions. From none of the many 'Schild' volcanoes of Iceland is explosive material known, and Herdubreid is no exception to the rule. Therefore I must conclude that not the gases but the magma itself has been the main force which led it to eruption. In the course of long-repeated gentle outflows it piled up the Herdubreid mass. But as no indication of a surplus of gases is recognizable in the erupted materials I think it most improbable that explosions, which would have drilled a cylindrical pipe through the ground—either on a fissure or beside it—took place during the origin of Herdubreid.

Thus the gradual ascent of lava with but little gas in a pipe must

have caused the first outbreak of Herdubreid, not the offshoot of an exploding mass of gases accompanied only by lavas. In this fact lies the great difference between Daubrée's experiment and the physics of eruption in the case of Herdubreid. With Herdubreid the cylindrical form of the pipe must therefore be due to other reasons than the ones adduced in the case of explosions.

Different reasons are possible. The most probable seems to me in accordance with Suess's and Branca's opinions, that the rising column of lava has forced its own way through the superincumbent crust until it reached the surface. But this or other explanations which see the moving force in the rising magma itself seem to me to negative the possibility of a fissure as a line of weakness being the outlet of an upward pressing magma, which would not in doing so assume the shape of a dyke, but would wear out a perfectly cylindrical canal along the fissure on its way upwards.

There are many more reasons to prove the fissureless nature of the Schild volcanoes in Iceland, but it is not the object of this paper to give them. The reader will find them published in the above-mentioned papers. Here I only wanted to show that I was well aware that this probably unique example in the world of a volcano being exposed on all sides a few hundred metres below its base, would be a serious objection to the theory which sees a fracture in the earth's crust as the necessary primary origin of all volcanoes. I therefore was especially careful in examining all the eventualities which could possibly have concealed a fissure below the volcano, but all observations as well as theoretical conclusions do not leave the least doubt that in this case volcanic force found its way to the surface without the help of a surface fissure. Furthermore, theoretical conclusions and comparisons of the products and the outer appearance of these lava volcanoes with the mechanics of eruption make it most probable to me that not even in the deeper parts of the crust a fracture has served them as a line of weakness; but that, probably by melting its way through the crust, the lava forced its own way from the magma basin below up to the eruptive point at the surface.

IV.—Preliminary Note on the Geology of South-Eastern Kincardineshire.

By Robert Campbell, M.A., B.Sc., Geological Department, University of Edinburgh.

THE district under consideration embraces that part of the county of Kincardine which lies south of the Highland fault. Excellent maps on the 1 inch and ¼ inch scale have been issued by H.M. Geological Survey, but no detailed description of the geology of the area has yet been published. Most of my vacations during the past three years have been spent in studying the geology of this interesting region, and although the work, which has included detailed mapping of the whole area on the 6 inch scale, is not yet complete, several points have been made out, the importance of which has led to the publication of this preliminary note.

Upper Cambrian (?).

Between Craigeven Bay and Garron Point occurs a series of crushed green igneous rocks with thin intercalated black shales, jaspers, and cherts, which are shown on the Geological Survey Maps as of Arenig (?) age. In August, 1909, on the occasion of a visit to Craigeven Bay in company with Dr. B. N. Peach and Mr. W. T. Gordon, we spent some time in searching for fossils in the above-mentioned sediments, and in the black shales we succeeded in finding organic remains, including a linguloid shell and a bivalve phyllocarid crustacean. The assistance of Mr. D. Tait, of H.M. Geological Survey, was obtained in making a detailed search in the fossiliferous beds. He collected a remarkable suite of fossils which have thrown important light on the age of these rocks. Dr. Peach, in whose hands the fossils were placed for determination, has very kindly supplied the following note:—

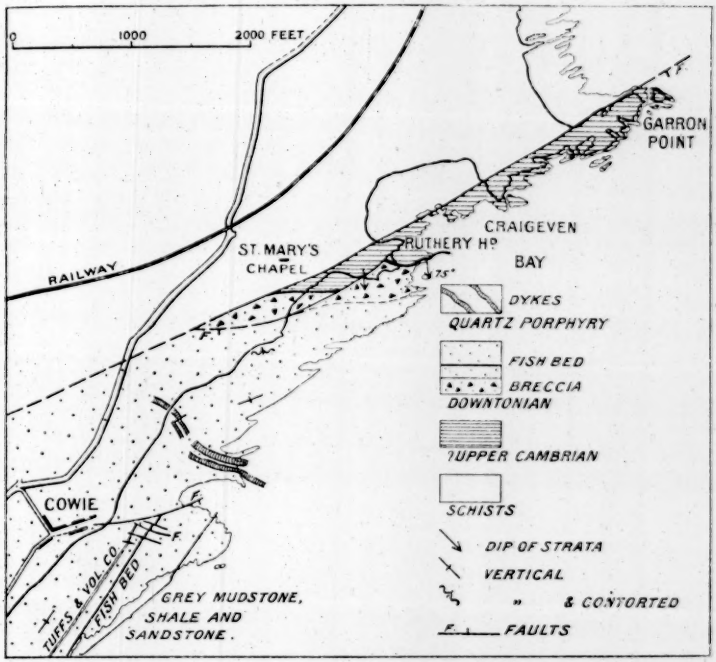
"The collection includes several specimens of hingeless brachiopods belonging to the genera *Lingulella*, *Obolella*, *Acrotreta*, *Linnarssonia*, and *Siphonotreta*; a few specimens of a bivalve phyllocarid allied to *Caryocaris* and *Lingulocaris*; cases of a tubicolar worm, the structure of the tubes being like that of the modern *Ditrupa*.

"Without further study it may be premature to express a definite opinion about the horizon of these fossils. The genera represented are most commonly found in the lowest division of the Lower Silurian (Ordovician) system and the Upper Cambrian. The absence of graptolites, however, suggests that they may belong to the latter rather than to the Lower Silurian."

These rocks extend as a narrow belt from St. Mary's Chapel to Garron Point (see Sketch-map). Whatever may be the ultimate decision as to their stratigraphical horizon, it will readily be admitted that the fossils must determine also the age of the similar groups of green crushed igneous rocks and associated sediments which occur at intervals along the Highland border.

The Highland Fault.

The Highland fault has hitherto been represented as a normal fault forming the boundary between the Old Red Sandstone formation and the older rocks to the north-west. A visit to the coast section at Craigeven Bay, in company with Dr. B. N. Peach, showed us that, along the south shore of the bay, what has hitherto been regarded as the Lower Old Red Sandstone formation rests unconformably on Upper Cambrian (?) strata. This boundary-line has always been looked upon as marking the line of the Highland fault, and, indeed, masked as the unconformity is by minor faulting and by the red staining of the underlying rocks, it is not perhaps surprising that the basement breccia has been mistaken for a fault breccia. The northern boundary of the Cambrian (?) is an overthrust fault, and this line of faulting is probably the continuation of the great Highland fault, which elsewhere in this district forms the northern limit of the Old Red Sandstone. In the only inland section in Kincardineshire in which the actual line of fault was seen—in a small stream near Elfhill, about 6 miles west of Stonehaven—the fault is undoubtedly an overthrust.



Sketch-map of Geology of the Coast of Kincardineshire from Cowie to Garron Point.

Upper Silurian (Downtonian).

Owing to the discovery of fossils in beds overlying the basement breccia, a considerable thickness of what has been regarded as Lower Old Red Sandstone must be considered as of Downtonian age. The succession of these rocks as shown in the coast section from Craigeven Bay to Stonehaven Harbour is as follows (in descending order):—

		Feet.
9.	Tuffs and volcanic conglomerate	300
8.	Brown micaceous sandstone	800
7.	Tuffs and tufaceous sandstone	800
6.	Grey sandstone and fossiliferous sandy shales and mudstones (with fish-band)	600
5.	Red sandstone	60
4.	Volcanic conglomerate and tuffs	40
3.	Grey and brown sandstones with thin red mudstones	1000
2.	Purple sandstone	60
1.	Basement breccia	200

The basement beds consist of breccias with intercalated thin red sandstones and sandy mudstones. The breccias are made up almost entirely of angular fragments of the igneous rocks and jaspers of the underlying Cambrian (?) strata, but they contain also occasional subangular and rounded pebbles of granite and schists. The unconformity which marks the base of the series may be traced along

the northern face of the headland at Ruthery Head, and thence in an easterly direction along the foreshore to low-water mark. Although the unconformable character of the junction is obscured to some extent, as noted above, still the marked difference in direction of the main structural lines in the two series of rocks is quite sufficient to allow of the unconformity being traced with absolute certainty. The planes of bedding in the Downtonian strata dip at a high angle to the south-south-east; the main structural planes in the Cambrian (?), both cleavages and bedding, in igneous and sedimentary rocks alike, dip towards the north-west. An overthrust fault which crosses Ruthery Head in a north-easterly direction shifts the outcrop of the lowest breccia 160 yards to the south-west. From this fault the unconformity can be traced for a considerable distance along the foreshore in a westerly direction (see Sketch-map).

While a detailed description of the whole succession cannot be attempted in a short preliminary paper, two further points will be dealt with.

1. The series of grey sandstones and sandy shales and green and grey mudstones (No. 6 in above table), alike in lithological character and in fossil contents, show quite clearly the Silurian rather than Old Red affinity of this succession. About 20 yards east of Cowie Harbour is a thick belt of grey and greenish mudstones and shale which yield *Dictyocaris* in great abundance. On visiting this section in August, 1909, in company with Dr. Peach and Mr. W. T. Gordon, we found not only *Dictyocaris* but also *Eurypterus* sp. and fragmentary plant-remains, and Mr. Gordon discovered in a thin bed of reddish sandy mudstone several fish-plates. Some of the fish-fragments were suggestive of *Birkenia*. Mr. Gordon and Dr. Peach joined me again during the past summer in order that we might try to get material sufficient to establish the horizon of this fish fauna. Considerable additions were made to the finds of the previous summer. The fishes were submitted to Dr. R. H. Traquair, who has been good enough to send me the following preliminary note:—

"The fish-remains from Cowie, Stonehaven, consist of—

"First: Small scutes which are about three times as long as they are broad, slightly convex on one side and correspondingly concave on the other, and apparently pointed at both ends. They seem to me to be referable to the category of Cephalaspidian scutes, only the external ornament, where visible, consists of longitudinal and slightly wavy striæ in place of tubercles. That the species to which they belong is as yet unnamed and undescribed is pretty certain, but the advent of additional material is desirable before proceeding further in that direction.

"Second: Several fragments of thin, minutely tuberculated plates which may also be Cephalaspidian, though their nature is indeed problematical.

"Third: Two median plates of a beautiful new *Cyathaspis*.

"The specimens from the grey sandstones overlying the fish-band consist of irregular blackish and reddish blotch-like films, which, on examination with a lens, show in many cases a honeycomb-like marking, consisting of minute polygonal areæ, whose margins are on one side

of the stone raised, on the counterpart incised. These markings are at once suggestive of the middle layer of the Pteraspidian shield, but in none of the specimens is any trace found of the inner layer or of the outer layer with its markings. More likely does it seem that these films are of the same nature as the problematic *Dictyocaris* of Salter from the Upper Silurian of the Pentland Hills, which occurs in similar blotch-like masses and shows very similar polygonal markings.

"As to whether the Cowie fish-remains indicate a Lower Devonian or an Upper Silurian (Downtonian) horizon, they in themselves afford no certain answer to the question, beyond this, that *Cyathaspis*, although it occurs in Lower Devonian rocks, seems, according to number of species, to be more characteristically a Silurian genus. If, therefore, the associated invertebrate remains favour the reference of these beds to the Downtonian horizon, that idea would be corroborated rather than the reverse by the relics of fishes noted above."

Apart from plant-fragments, worm-tracks, and *Dictyocaris* the remaining fossils belong to the Arthropoda. They include *Ceratiocaris* sp. (carapace, rostrum, and cercopod); *Archidesmus* sp. and a new genus of Myriopod; (?) larval form of insect; *Eurypterus*, sp. nov.; fragments of scorpion. These Arthropoda will be described by Dr. Peach, to whom I am indebted for the above provisional determination.

Although the typical Downtonian fishes of the south of Scotland have not so far been met with in Kincardineshire, yet the occurrence of *Ceratiocaris* and *Dictyocaris*, neither of which has hitherto been found in rocks younger than Upper Silurian, would appear to indicate that these Cowie beds are of Downtonian age. This view, as pointed out by Dr. Traquair, is apparently corroborated by the association of these fossils with *Cyathaspis*.

Since I returned to Edinburgh I have learned from Dr. Horne that in 1881 Mr. MacConnochie, of H.M. Geological Survey, collected from the 'Stonehaven Beds' on the shore near Cowie, and from the prolongation of the same beds exposed in the Carron Water, west of Tewel, specimens of *Dictyocaris*, together with fragments of *Pterygotus*, *Eurypterus*, and (?) *Kampecaris*. From the abundance of the remains of *Dictyocaris* Dr. Peach at that time suggested that the beds containing these fossils might be of Upper Silurian age.

2. In the excellent account of the volcanoes of Lake Caledonia in his *Ancient Volcanoes of Great Britain*, Sir Archibald Geikie[1] has correlated the initial outbreak of volcanic activity with the coming on of the conditions which gave rise to the massive quartzite conglomerate south of Stonehaven Harbour. That volcanoes were active in this area at a much earlier period is seen from the great development of tuffs and volcanic conglomerates in the Downtonian sequence. The lowest volcanic conglomerate is about 2,500 feet below the above-mentioned quartzite conglomerate. It can be traced inland until it is lost against the Highland fault, and everywhere the

[1] *Ancient Volcanoes of Great Britain*, vol. i, p. 303.

predominating constituents in the conglomerates and tuffs are rhyolites and hornblende-biotite andesites. It seems clear, then, that early in Downtonian times (or perhaps in pre-Downtonian) rhyolites and acid andesites flowed out in abundance over the schist and granite country to the north of the Highland fault. Further evidence of the existence of this series of volcanics is obtained from the character of the sediments of the Lower Old Red Sandstone formation.

The highest beds in the above table pass conformably up into the massive quartzite conglomerate of Downie Point, which may be considered as the base of the Lower Old Red Sandstone.

Lower Old Red Sandstone.

While the palæontological evidence here is so meagre that it affords little assistance, lithological evidence, on the other hand, obtained from conglomerates, lavas, and tuffs, has aided materially in elucidating the structure of the area occupied by the Lower Old Red Sandstone.

The conglomerates fall into two well-marked classes: (1) those in which quartzites or other 'Highland' rocks predominate; (2) those which are made up almost entirely of volcanic rocks—volcanic conglomerates. Detailed examination of the character and distribution of these conglomerates is being carried out. Meanwhile mention may be made of some points which are of especial interest.

In the 'Highland' conglomerates at different horizons occur numerous pebbles of greywacké, including many of the 'Haggis Rock' type, showing just as little evidence of schistosity as the greywackés of the southern uplands. The boulders of 'Haggis Rock' consist chiefly of angular and subangular fragments of jasper, chert, and 'green rocks' (probably spilitic lavas), the rock types which predominate in the Cambrian (?) Series at Craigeven Bay. In all probability these boulders have been derived from the Margie Series described by Mr. Barrow.[1] All the 'Highland' conglomerates contain boulders of the jasper-green rock series. In many of the conglomerates low down in the succession these rocks are almost the only types represented; it is only in the highest conglomerates that they begin to play an insignificant part. The evidence given by these conglomerates seems to point conclusively to a former wide extension of Cambrian (?) and Margie rocks over the country now occupied by the granites and Dalradian schists.

Thick volcanic conglomerates, the pebbles of which are chiefly acid andesites and rhyolites, occur at three different horizons, and, in one case at least, the conglomerate has its maximum development at the Highland fault. Further, the sandstones at every horizon contain invariably a considerable amount of the debris of rhyolites and acid andesites. Here again, as in the Downtonian succession, there is evidence of long-continued denudation of a series of acid lavas, which must have extended far to the north of the Highland fault.

Only one limestone has been noted in the Lower Old Red Sandstone succession. It occurs at several localities in the Howe of the Mearns,

[1] Q.J.G.S., vol. lvii, p. 331, 1901.

and probably occupies the same horizon as a limestone which has been mapped by H.M. Geological Survey for several miles in the Plain of Strathmore.

Fossils have been collected from four horizons. The above-mentioned limestone has yielded plant fragments, while in the associated red flagstones worm-tracks have been observed. In a series of grey and greenish sandstones and mudstones in Den of Morphie, *Parka decipiens* occurs in great abundance, along with *Kampecaris forfarensis* and fragments of *Pterygotus anglicus*. The sandstones at Three Wells Quarry, near Bervie, separated from the above fossiliferous beds by a thick series of hypersthene and augite andesites, have yielded specimens of *Cephalaspis Lyelli*. From the grey sandstones in Strathlethan Bay, which immediately overlie the lowest quartzite conglomerate, specimens of *Parka* sp. have been obtained.

Evidence of prolonged volcanic activity is found in the great development of lavas, tuffs and agglomerates, and hypabyssal intrusions. The lavas include one flow of rhyolite and at least two of hornblende-biotite andesite. The predominating types, however, are basic, and consist of hypersthene andesites, augite andesites, and basalts. The tuffs are all acid in character. The hypabyssal intrusions of presumably Lower Old Red Sandstone age include quartz porphyries, porphyrites, lamprophyres, and dolerites.

The main structural feature is a continuation of the well-known synclinal fold of Strathmore. In the area to the west of Elfhill, however, there is a tendency to set up a steep-limbed anticline pitching out to the south-west against the Highland fault. The southern limb of the syncline is traversed by numerous powerful dip faults.

Upper Old Red Sandstone.

In the neighbourhood of St. Cyrus on the Kincardineshire coast there is an outlier belonging to the Upper Old Red Sandstone Series. Although no fossils so far have been recorded, the type of sedimentation leaves no doubt as to the age of these rocks. Their junction with the Lower Old Red Sandstone Series is shown on the Survey maps as a natural boundary. In his description of the coast section Mr. George Hickling [1] has pointed out that the southern boundary is a fault, and he suggests that the northern boundary either is a fault or the Upper Series is banked up against an old cliff of the Lower. It has been found that the former supposition is the correct one.

Dykes later than Old Red Sandstone.

A number of quartz dolerite dykes have been mapped which have a general east-north-east and west-south-west trend. They are of the same type as the widely distributed east and west dykes of the central valley of Scotland.

[1] Geol. Mag., Dec. V, Vol. V, p. 405, 1908.

V.—On the Teeth and Buccal Structures in the genus *Conulus*, Leske.

By Herbert L. Hawkins, B.Sc., F.G.S.

(PLATE III.)

THE question as to the existence and characters of the jaws in *Conulus albogalerus*, Leske, has long been a subject of controversy. On prima facie evidence it seemed probable, so long as the genus was retained among the Holectypoida (the Galeritidæ of older authors), that jaws existed. *Conulus* appears as a successor to *Discoidea* among the Cretaceous Echinoids, and, with a few exceptions, all echinologists admitted that the latter genus was armed with a lantern and teeth. The truth of this assumption was proved by Lovén (Lovén, 1892, p. 53), and the details of the jaw structure were elaborated recently by myself in this Magazine (pp. 148–52, Pl. VI, 1909). That *Conulus* should be classed among the Holectypoida seems to be an established proposition, and it appeared in the early part of the Cretaceous period, together with *Pyrina*, probably as an offshoot from the *Holectypus* line of descent.

The history of the search for jaw-structures in *Conulus* shows some of the most remarkable contradictory results that are to be met with in the whole range of the study of fossil Echinoids. In 1829 Charles Stokes, in a letter published (in extract) in the Geological Society's Transactions (Stokes, 1829), announced the discovery, in '*Galerites*' (*Conulus*) *albogalerus*, of structures which he called 'plates of the mouth'. His figure is quite clear, and these structures (now known as 'buccal plates') have been found in many specimens since that time. Des Moulins, in the first of his memoirs on Echinoids (Des Moulins, 1835, pp. 191 and 324), referred to Stokes' account, and was undecided as to whether the structures were teeth or jaws. Grateloup (1836, p. 159) classes *Galerites albogalerus* among those species which have the 'bouche armée'. Desor expressed the opinion that the structures were the extremities of jaws (Desor, 1842, p. 13), and copied the figure.

The first definite statement on the subject was made in 1850 by Edward Forbes, who described and figured (Forbes, 1850, p. 3) the jaws and teeth. Desor (1857, p. 181) seems to have accepted the validity of this observation. The figures of the teeth are not very convincing, but they were copied by d'Orbigny in the *Paléontologie française* (d'Orbigny, 1859, pl. 996, figs. 9–10), and by Wright (1874, pl. 1, figs. 5–6). Wright held that the buccal plates were vestiges of a true 'lantern'. Lovén, in his *Études sur les Echinoidées* (Lovén, 1874), placed the 'Echinoconidæ' among the 'Échinoidées à dents'.

The first denial of the presence of jaws came in 1884, when Duncan, in a somewhat dogmatic paper, attacked the foundation of the figures and descriptions given by Forbes and Wright, and denied the possibility of the existence of dentigerous jaws in *Galerites* (*Conulus*) *albogalerus* (Duncan, 1884, p. 11). He established the fact of the presence of tubercles on the outer surface of the buccal plates (which seemed to preclude their derivation from any part of the

lantern), and, basing his observations on some specimens in the British Museum, maintained that the teeth described by Forbes were imaginary, or founded merely on grooves caused by a tool in the soft chalk within the peristome. As a result of his conclusions he placed '*Galerites*' among the Echinonidæ.

Following on so uncompromising a denial, almost all subsequent writers have regarded *Conulus* as a toothless form. In 1900 Gregory took this view (Gregory, 1900, p. 316), although retaining the family Galeritidæ among the Holectypoida, while in the same year Sladen placed the genus among the Echinonidæ (Sladen, 1900).

With the exception of the last two references, which are of a general character, all the discussion was concerned with *Conulus albogalerus*, one of the latest members of the genus, and certainly the most readily obtained and studied in this country. A small, tumid form of this species is very abundant in the uppermost layers of the zone of *Micraster coranguinum* in the South of England. I recently collected more than fifty specimens from this '*Conulus* band' in a chalk-pit near Kingsclere, and neither in the interior of the specimens nor in the matrix in which they were so thickly scattered could I detect the smallest trace of any structures comparable with normal Echinoid jaws. In the case of one specimen, in which the buccal plates were in situ, and by their presence narrowed the mouth opening to a very small circle, there was no macroscopic fossil inside the test excepting two stray buccal plates which must have drifted in with the infilling chalk.

I made this search as a result of the discovery by the late A. Agassiz of teeth and a lantern in a young specimen of *Echinoneus* (Agassiz, 1909). After having destroyed fifty specimens and rubbed down (with a brush) a very considerable quantity of their matrix with no result, I came to the conclusion that Duncan was justified in his scepticism. It was therefore with great surprise that, on examining a series of *Conulus subrotundus*, Mantell, in the British Museum, I found a specimen[1] with the peristome enlarged by cutting and four glistening, enamel-like teeth projecting towards the aperture. Whether this specimen is the one on which Forbes based his account of teeth in the newer species, or not, is a question which seems unanswerable. There is no information as to the locality from which the specimen was collected, nor as to whose hand cleared out the peristome. (The only information with the specimen was 'Upper Chalk', which is almost certainly inaccurate.) If, however, this should be the example referred to, the figures given in the Decade (pl. viii, fig. 10), and subsequently copied by d'Orbigny and Wright, owe a great deal to the imagination of the artist.

The specimen is of the form of *C. subrotundus*, found most frequently in the zone of *Terebratulina*, being tall, inflated at the sides, and rounded at the margin of the adoral surface. Judging from the intense hardness of the chalk within the test, it would seem to belong rather to the zone of *Rhynchonella Cuvieri*. It is, at least, safe to ascribe it to the Middle Chalk. It seems to be fully adult. For

[1] The specimen has been registered E. 10743.

some little distance within the peristome the chalk filling is soft and crumbling, but otherwise it is very hard.

After slicing off one side of the specimen I was able to develop the peristomial region in such a way that it could be viewed from the side. The appearance of the teeth after this operation is shown in Pl. III, Fig. 1. I subsequently extracted two of the teeth for detailed examination, and the following description is founded on these two examples only. The others seem identical in character.

The teeth are composed of extremely hard calcite with a porcellanous lustre. The more complete of the two specimens (Pl. III, Figs. 2–5) measures 6·7 mm. from the (accidentally) blunted tip to the inward end of the internal carina. The other is 7·0 mm. long, and has the point intact, but the rest of the tooth is not very well preserved. Except towards the tip, where for a distance of 1 mm. they taper to a point, both teeth have a uniform width of 1·4 mm.

The curvature of the whole tooth is very slight, as shown in Fig. 2. The convex surface is marked by a fairly prominent ridge (with angular margins) down the middle line, and two less conspicuous ridges down the edges. On the concave surface, which is slightly hollowed, there is an extremely prominent carina, which rises abruptly at a distance of 1 mm. from the point of the tooth, and in both specimens persists upwards beyond the blade.

It will be noticed that the above description agrees fairly closely with that given by Forbes in 1850. The teeth are strikingly similar to those of *Discoidea cylindrica* which I described a short time ago (Geol. Mag., 1909, p. 149, Pl. VI, Fig. 4). The length of these new specimens is greater than that in the case of *Discoidea*, but owing to the fact that all are broken, this is a point of no importance. The width of the *Discoidea* tooth is only ·9 mm., as against the 1·4 mm. in the *Conulus* examples. The extreme sharpness of one of the *Conulus* teeth shows a contrast to that of *Discoidea*, but the bluntness in the latter case (certainly not due to fracture) may have been the result of wear. The most important difference between the two genera, in the matter of their teeth, is the almost straight shape of the tooth in *Conulus*. I have copied the figure of the side view of the *Discoidea* tooth (reduced to the same scale as the others) to render this contrast more obvious. See Pl. III, Fig. 6.

In spite of the most careful search and very gradual development of the specimen, I found no trace whatever of jaws or any other structures beside the teeth. Although it seems impossible that teeth of such dimensions could exist, and especially be functional, in the absence of jaws for their support, yet it is almost less conceivable that they could have remained within the test while the jaws slipped through the peristome after the animal's death. An explanation of this apparent anomaly might perhaps be found in a suggestion that the jaws had advanced so far in degeneration that they were no longer calcareous, but I know of nothing in recorded jaw-structures that would support such a view.

The presence of teeth in *Conulus subrotundus* is established beyond doubt by the discovery of this specimen, but the question still remains

as to whether similar structures existed in *C. albogalerus*. I have indicated above the strong negative evidence afforded by their absence in fifty specimens, in one of which the buccal plates remained intact. But such evidence is, of course, unsatisfactory. I can find no record of buccal plates having been detected in *C. subrotundus*, nor have I found traces of them among several hundred specimens, many very perfectly preserved, that I have examined. The perignathic girdle in this species is similar to that in *C. albogalerus*, but I have not found the small adradial process of the latter represented in the specimens dissected.

Duncan based part of his argument against the existence of jaws and teeth in *C. albogalerus* on the assumption that the buccal plates narrowed the mouth aperture to such an extent that there was no room for jaws to exercise their functions. The preparation of the peristome in the specimen above referred to, from the upper part of the zone of *M. coranguinum* (Pl. III, Fig. 7), shows the buccal plates from within, a view which, I believe, has not hitherto been described. Each plate has a deep pit in a groove towards the ambulacral margin. (Externally there are two tubercles in sunken areolæ, like those of the test.) The plates are roughly triangular, and each pair is in contact along almost the whole interradial margin. The position of the plates with regard to the grooves in the perignathic girdle suggests that they could slide up these, and so enlarge the diameter of the mouth opening. If this were the case, then perhaps a muscle was attached in the pit on the plate, and passed to the small adradial process of the girdle. Such an arrangement might conceivably be a modification from the characters and muscle attachments of the pyramids of a lantern, and then each buccal plate would be a degenerate demi-pyramid. The presence of tubercles on the outer surface is the only feature seriously antagonistic to this view. As buccal plates of this kind are not known in any other genus or species, living or extinct, it seems probable that the development of these tubercles is secondary, consequent on the external position of the plates, and that the buccal plates really are curiously modified remains of the jaws. If this were to be demonstrated by future discoveries, it would be difficult to understand how teeth could find their place in such pyramids, although the retractability of the plates would remove the difficulty of the small size of the oral aperture.

If buccal plates were to be found in *C. subrotundus*, there would be no reason why teeth should not occur in *C. albogalerus*, but in the absence of these structures in the earlier species, the following summary of the suggestions made here may show some approximation to the actual conditions.

Summary. *Conulus subrotundus* had teeth, of a type differing but little from those of *Discoidea cylindrica*, but the remaining parts of the jaw apparatus were either uncalcified or too delicate for preservation. *Conulus albogalerus*, developing along a somewhat different line, lost its teeth, but retained the pyramids of the jaws, modified to form buccal plates.

In conclusion, I wish to express my thanks to Dr. F. A. Bather, F.R.S., for his help and advice, and to Mr. T. H. Withers for the gift of several

specimens collected by himself which have been used to confirm my observations.

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EXPLANATION OF PLATE.

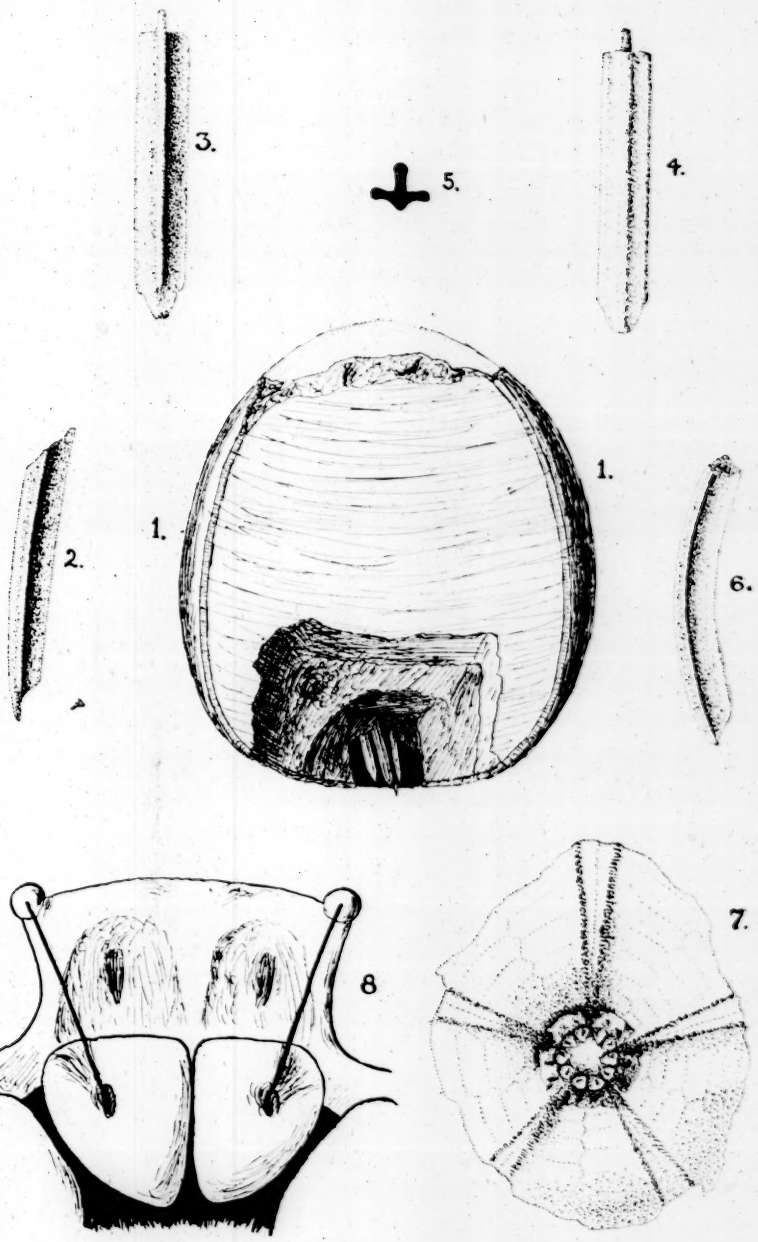
FIG. 1. Sketch of the specimen of *Conulus subrotundus* (in British Museum), showing the teeth in situ. × 1½.
,, 2. Side view of tooth of same. × 6.
,, 3. Inner (concave) view of tooth. × 6.
,, 4. Outer (convex) view of tooth. × 6.
,, 5. Section of tooth. × 6.
,, 6. Side view of tooth of *Discoidea cylindrica*, for comparison with Fig. 2. × 6.
,, 7. Inner view of perignathic girdle and buccal plates of *Conulus albogalerus*. × 2.
,, 8. Diagrammatic sketch of the suggested method of movement of the buccal plates. The dark lines represent the positions of the retractor muscles.

VI.—FOSSIL MYRIOPODS FROM THE MIDDLE COAL-MEASURES OF SPARTH BOTTOMS, ROCHDALE, LANCASHIRE.

By WALTER BALDWIN, F.G.S., M.Inst.M.E., Government Geologist, Gold Coast, West Africa.

(PLATES IV AND V.)

IN the GEOLOGICAL MAGAZINE for December, 1907, a brief account was given by Dr. Henry Woodward, F.R.S., of the work of a small committee of Littleborough and Rochdale geologists, who have for several years been engaged in an examination of the Arthropod Beds at Sparth Bottoms, Rochdale. At Sparth Bottoms several beds



H. L. Hawkins del.

Jaw structures in *Cucullus*.

of greyish-blue shale, containing clay-ironstone nodules, crop out; the nodules have yielded to the hammer a surprisingly large number of new forms of Arthropoda, some of which have already been figured and described, and others still require further investigation. The beds exposed in the quarry are estimated by the author as 135 to 180 feet above the Royley Mine Coal Seam.

The following is a list of the Arthropoda which have been obtained from these beds:—

	Individuals.
Crustacea.	
Belinurus lunatus, Martin, olim *B. bellulus*, König	250
B. Königianus, H. Woodw.	20
B. Baldwini, H. Woodw.	3
B. longicaudatus, H. Woodw.	2
B. testudineus, H. Woodw.	2
Prestwichia Birtwelli, H. Woodw.	36
P. (Euproöps) Dance, Meek & Worthen	2
P. rotundata, var. *major*, H. Woodw.	25
P. rotundata, Prestwich, sp.	
P. anthrax, Prestwich, sp.	10
Pygocephalus Cooperi, Huxley	2
P. (Anthrapalæmon) Parkeri, H. Woodw.	1
Anthrapalæmon (?) sp.	2
Dithyrocaris sp., Scouler	4
Eurypterus sp.	fragments.
Arachnida.	
Eoscorpius Sparthensis, Baldwin & Sutcliffe	1
E. (Mazonia) Wardingleyi, H. Woodw.	1
Eobuthus (?) rakovnicensis, Fritsch	1
Geralinura Sutcliffei, H. Woodw.	1
Anthracomartus trilobitus, Scudder	5
A. sp.	2
Anthracosiro Woodwardi, Pocock	1
Architarbus subovalis, H. Woodw.	1
Cyclus Johnsoni, H. Woodw.	81
Myriopoda.	
Xylobius Platti, Woodw.	1
Archiulus sp.	1
Euphoberia ferox, Salter, sp.	1
E. armigera, Meek & Worthen	1
E. robusta, Baldwin, sp. nov.	1
E. Woodwardi, Baldwin, sp. nov.	1
Acantherpestes major, Meek & Worthen	1
A. giganteus, Baldwin, sp. nov.	1
Insecta.	
Stenodictya lobata, Brongniart	1

By the courtesy of my friend Mr. W. A. Parker, F.G.S., of Rochdale, several specimens of Myriopods have been placed in my hands for examination. They were all obtained from the beds at Sparth Bottoms, and the gentlemen who discovered them have kindly permitted me to figure and describe them. The specimens were all enclosed in clay-ironstone nodules, and were exposed by splitting the concretions open along their periphery.

TRACHEATA (Air-breathers of the Coal Period).

ARCHIPOLYPODA, Scudder.

Fam. 2. *EUPHOBERIDÆ*, Scudder.

Genus *Acantherpestes*, Meek & Worthen, Geol. Surv. Illinois, vol. iii (Palæontology), 1868, p. 556.

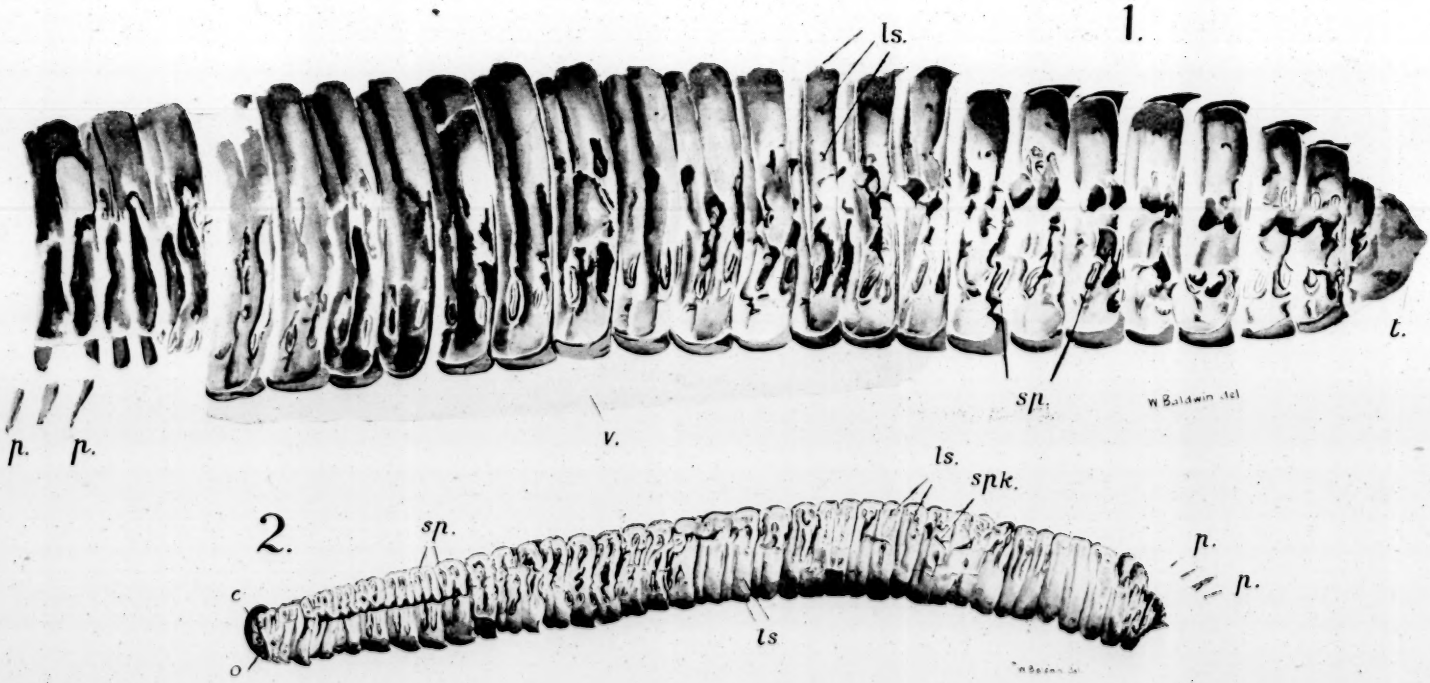
1. ACANTHERPESTES GIGANTEUS, Baldwin, sp. nov. (Pl. IV, Fig. 1.)

This enormous specimen, which is to be presented to the Manchester Museum, and of which a figure is given here (Pl. IV, Fig. 1), was discovered by the author at Sparth Bottoms last June, and is contained in a large nodule weighing about 9 lb. 3 oz. Both sides of the nodule are preserved, and expose the dorsal view of a Myriopod, having indications of the tail and about twenty-five segments, measuring a total length of 195 mm. The telson (?) appears to possess a broad saddle which terminates in the middle in a three-cornered area that is very suggestive of *Acantherpestes gigas* (Fritsch).

Each dorsal segment is divided transversely into two parts by a furrow which extends to within a short distance of the lateral margin, dividing the segment into two portions in the proportion of 2 to 5. The anterior position is arched, whilst the posterior portion is curved to a height of 1·5 mm. The lateral borders of each segment are occupied by a broad depressed margin prolonged backwards into a triangular area very reminiscent of *Arthropleura*. The posterior portion of each segment bears bosses and scars, representing three rows of spines on each side of the body. The segments are all nearly of equal length, averaging 7·5 mm., their breadth varies from 18 to 44 mm., but the latter measurement should actually be considerably modified on account of the crushed state of the specimen. The change in breadth of the body is very marked, and occurs in the last four or five segments (this is probably caused by the loss of a part of the margin of these last segments, and by their slight dislocation).

The surface is apparently smooth, but when viewed with a strong lens under a favourable light is found to be minutely granular. In many places the surface integument has disappeared, revealing portions of the interior faces of the ventral plates, thereby exposing large ovate oblong spiracles that run transversely through the body, containing a deep groove with a thin laminate ridge along the middle; they are 2·75 mm. long and 0·75 mm. broad. On either side of the medio-ventral line of the body, and almost attingent at their slightly swollen bases, are the branchial cups, which appear as sunken pits, triangular in form. A few pairs of ambulatory appendages can be made out, two pairs being attached to each segment; they are stout, 2 mm. broad, and probably attained 21 to 22 mm. in length. One side of the specimen is very much flattened, and for about a length of thirteen segments a dark stain is observed next to the lateral border, and probably represents the soft portions of the animal which have been squeezed out by pressure.

This species differs from *A. major* in the shape of the segments, and is easily recognized on account of its enormous size, hence the trivial name.



Fossil Myriopods from the Middle Coal-measures, Sparth, near Rochdale. Nat. size.

Genus *Euphoberia*, Meek & Worthen.

2. Euphoberia armigera, M. & W. (Pl. V, Fig. 4.)

The specimen (discovered by Mr. Parker) of which a figure is given here (Pl. V, Fig. 4) appears to be identical with *Euphoberia armigera* of Meek & Worthen, and will be shortly presented to the Manchester Museum. Both sides of the nodule are preserved and reveal a lateral view of the Myriopod.

The intaglio exposes a clearer view of the creature and has been figured accordingly; there are indications of thirteen or fourteen dorsal segments, together with about nineteen ventral segments. The thirteen dorsal segments measure 39·5 mm., and taper uniformly towards the anterior end; they are equal in length (3 mm. each) and vary in breadth from 4 to 7·5 mm., being divided by a transverse depression in the proportion of 2 to 1, the broader or anterior portion showing indication of being spiniferous. The ventral plates, two to each dorsal segment, are somewhat blurred, average 1·5 mm. in length, and are about four times as broad as long. Fragments of about twenty-one legs are indifferently preserved. The body surface is smooth to the naked eye, but under a strong lens appears slightly granular.

The creature is attached to a portion of a stem of *Cordaites*, the whole being contained in a clay-ironstone nodule subovoid in shape, 70 mm. long by 60 mm. broad and 35 mm. thick.

3. Euphoberia robusta, Baldwin, sp. nov. (Pl. V, Figs. *3a*, *b*.)

This large Myriopod (Figs. *3a*, *b*) is contained on the relief half of a clay-ironstone nodule weighing about 1 lb. 10 oz. The creature is seen to be coiled dorsally, and measures 59·5 mm. in length as it lies on the stone, but would measure 68 mm. if extended. About seventeen segments are seen in front of the tail (?), but all somewhat flattened. At the broadest portion the segments are 18 mm. wide and at the narrowest 9 mm., whilst in length the segments vary from 3·6 to 2 mm.

The first eight segments preserved (except the first, which is broken) are of nearly uniform width, being 18 to 16 mm., with an average length of 3·6 mm.; after the eighth segment the Myriopod gradually tapers, presenting a very fusiform appearance, the dimensions being as below :—

	Width. mm.	Length. mm.
Ninth segment	15·5	3·60
Tenth segment	15	3·50
Eleventh segment	14	3·25
Twelfth segment	13	3·00
Thirteenth segment	12	2·75
Fourteenth segment	11	2·50
Fifteenth segment	10	2·25
Sixteenth segment	9	2·00
Seventeenth segment	?	?

The segments are divided into two parts, the anterior two-thirds being slightly arched and spiniferous, whilst the posterior third is strongly arched and rises to an equal elevation with the former; the dividing furrow is deep. The surface is smooth, but presents minute pittings. The position of the lateral spines is indicated by small tubercles 0·5 mm. diameter, situated at about 2·75 mm. from the edges of the segments. The sub-dorsal rows are only indicated by a few pits, and appear at about 5 mm. distant from the lateral rows. The telson (?) is very badly preserved, but appears to be rounded.

On some of the segments the outer covering has decayed in such a manner as to expose portions of the interior of the ventral plates, revealing large oblong ovate spiracles that run transversely to the body and show as a deep groove with a thin laminate ridge along the middle; they are 1·5 mm. long and 0·4 mm. broad.

This species for size somewhat resembles *E. hystricosa* (Scudder), but is at once distinguishable by the shape of the dorsal segments. The stout and massive appearance has suggested to me the trivial name. This fossil was also discovered by Mr. Parker, who is presenting it to the Manchester Museum.

4. Euphoberia Woodwardi, Baldwin, sp. nov. (Pl. IV, Fig. 2.)

For the fourth example (Pl. IV, Fig. 2), which was found in the same measures, I am indebted to Mr. F. Howard, of Rochdale, who has very kindly placed the specimen from his collection at my disposal for purposes of examination and description. The Myriopod is exposed dorsally and measures about 12·4 cm. as it lies in the stone, and is represented by a head and thirty-eight segments measuring 7·5 mm. just behind the head.

The head, which is bent under, is broad, quadrate, with large oblique, many-celled eyes. The eye forms an oval boss 3 mm. long and 1·75 mm. broad, situated towards the anterior portion of the head, its longer axis vertical; it is covered with nearly hemispherical, circular cells, 0·5 mm. in diameter, crowded closely together, but not attingent, showing a slight indication of serial arrangement. Lying between the eyes is a well-marked circular depression 1·5 mm. in diameter, surrounded by an arched furrow that extends diagonally towards the anterior of the head, forming a four-sided plate that is very suggestive of Fritsch's *Acantherpestes gigas*. No antennæ are visible.

The seven segments succeeding the head gradually increase in breadth from 9 to 12·5 mm. and are of equal length (3·5 mm.). The remaining segments have a uniform breadth of 13 mm. and each measures 3·5 mm. long. Each segment is divided by means of a transverse furrow into two portions, a shorter anterior which is arched and a longer posterior which is flat, in the proportion of about 1 : 2. The posterior portion is spiniferous, the spines being indicated by blunt tubercles, forming two rows along each side of the body about 3 mm. apart. The spines appear (I have only been able to trace one and a few fragments detached) to be about 3 mm. long, consisting of a main stem that bifurcates at about two-thirds from the base, throwing off a branch about 1 mm. long at an obtuse angle. Both the main branch and the stem are slender.

The surface appears smooth, but in one or two places a delicate granulation may be seen, and a few segments exhibit a feeble wrinkling or faint corrugation of the surface.

Where the surface has been worn away hollow coxal cavities are exposed, and outside these are the large oblong ovate spiracles running transversely to the body, with a thin laminate ridge along the middle of each; they are about 1 mm. long and 0·5 mm. broad. The posterior end of the fragment exhibits portions of legs that indicate they are slender as compared with the bulk of the creature.

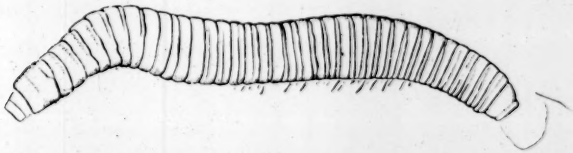
I have named this very interesting Myriopod after Dr. Henry Woodward, to whom students of fossil Arthropoda are so much indebted.

Fam. 3. *Archiulidæ*, Scudder.

Genus *Xylobius* (Dawson).

Xylobius Platti (H. Woodward).

A fifth and very perfect Myriopod (see Text-figure) discovered by Messrs. Sutcliffe & Parker and recorded by Dr. Henry Woodward at the British Association meeting, York, 1906, was named *Xylobius Platti* by Woodward in honour of the local work done by Mr. S. S. Platt, F.G.S., of Rochdale. It has been presented to the British Museum (Natural History), where it is registered [I. 13738]. I now append a figure and a short description of this interesting gally-worm. Length 50 mm. as it lies on the stone, or 54 mm. if extended, semicircular form, body cylindrical, of nearly uniform



Xylobius Platti, H. Woodw. MS. [Brit. Mus. I. 13738.] Middle Coal-measures: Sparth, near Rochdale. × ½ nat. size. Drawn by Miss G. M. Woodward.

width throughout the principal part, but slightly tapering towards either end. Consists of about forty-two segments. Breadth of body 3·50–6·5 mm. The head and two posterior segments measure 2·4 mm. The segments are a little convex, averaging 1·5 mm. in length per segment, their length to breadth as 1 : 4. Surface nearly smooth, frustra only slightly preserved. Both anterior and posterior borders slightly incrassated. Two pairs of legs to each segment, but not well preserved.

This species is nearly related to *Xylobius mazonus* of Scudder, from the Coal-measures of Mazon Creek, Illinois,[1] but in the American specimen the segments are more numerous, numbering as many as fifty; they are more parallel-sided, and their ornamentation of fine

[1] See S. H. Scudder, Mem. Boston Soc. Nat. Hist., vol. iv, No. 9, pp. 439–40, pl. xxxvii, figs. 7–11; and K. Zittel, *Handb. d. Palæont.*, I, ii, p. 730, fig. 902, 1885.

transverse parallel lines is not so conspicuous as in Scudder's specimen. The head in the Sparth example is also smaller.

In conclusion, I beg to thank Dr. Henry Woodward for his kind assistance whilst preparing this paper, and those gentlemen who have so obligingly placed the material for description at my disposal.

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EXPLANATION OF PLATES IV AND V.

Plate IV.

Fig. 1. *Acantherpestes giganteus*, W. Baldwin, sp. nov. Nat. size. Middle Coal-measures: Sparth, near Rochdale. *l.s.* bases of spines; *p.p.* walking-feet; *sp.* spiracles; *t.* telson; *v.* stained surface probably due to extrusion of viscera.

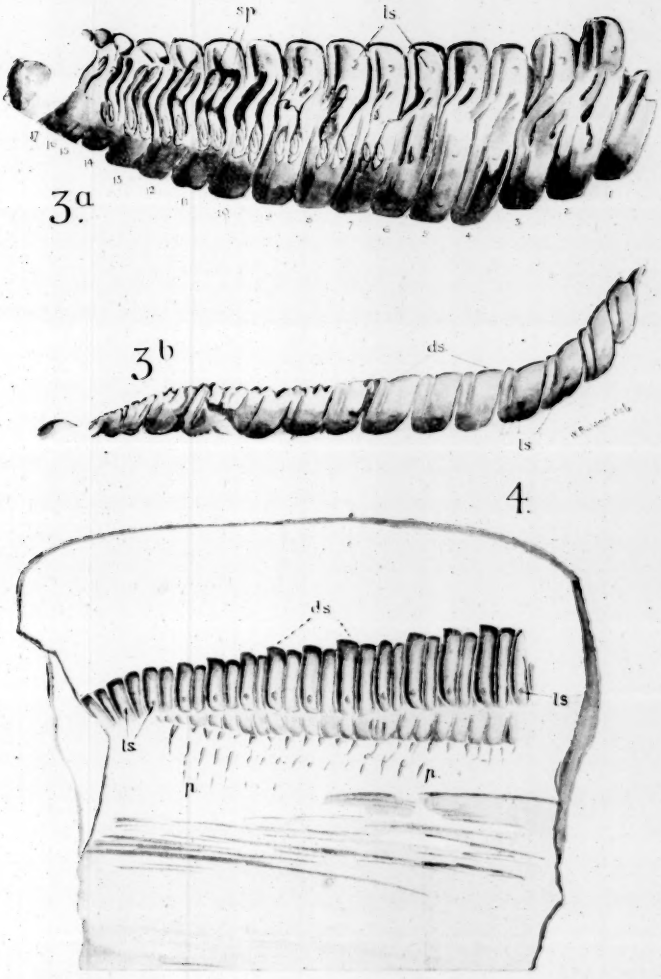
,, 2. *Euphoberia Woodwardi*, Baldwin, sp. nov. Nat. size. Middle Coal-measures: Sparth, near Rochdale. *l.s.* bases of spines; *p.p.* walking-legs; *spk.* spine (?); *c.* head; *o.* ocelli; *sp.* spiracles.

Plate V.

,, 3*a*. *E. robusta*, W. Baldwin, sp. nov. Dorsal surface. Enlarged 1½ nat. size. Middle Coal-measures: Sparth Bottoms, near Rochdale. *sp.* spiracles; *l.s.* bases of spines.

,, 3*b*. *E. robusta*, showing lateral view. Enlarged 1½ nat. size. *d.s.* dorsal surface; *l.s.* bases of spines.

,, 4. *E. armigera*, Meek & Worthen. Enlarged 1½ nat. size. Middle Coal-measures: Sparth, near Rochdale. *d.s.* dorsal surface; *l.s.* bases of spines; *p.p.* walking-legs.



W. Baldwin del.

Fossil Myriopods, Middle Coal-measures, Sparth, near Rochdale.
1½ nat. size.

VII.—Glaciers of the Yakutat[1] Bay Region, Alaska.

By R. M. Deeley, Memb. Inst.C.E., F.G.S.

THE United States Geological Survey has issued a paper, by Professor R. S. Tarr, of Cornell University, on the Physiography and Glacial Geology of the Yakutat Bay Region of Alaska. Here we have high coastal ranges, culminating in Mounts Cook and Seattle, from which descend great glaciers to the sea, and also other glaciers which come down to the waters of Russell Fiord. The whole region shows signs of intense glaciation during quite recent times, and on this account is an admirable area for the study of glaciers and their work.

That geology is still a living science is proved by the fact that we are not yet quite agreed upon many important points. That glacial geology is one of those matters about which there is at present a great deal of difference of opinion will be seen by anyone reading the Rev. Professor Bonney's Address to the British Association at Sheffield last year. Of late years in this country many geologists have been inclined to attribute very little erosive power to glaciers. A few, on the other hand, are of opinion that glaciers are quite powerful eroding agents, and consider that they have deepened valleys, excavated many lake-basins, and produced physical features which the ordinary atmospheric influences are now rapidly modifying. Under these circumstances the views formed by Professor Tarr, after a thorough study of a most instructive region, should be of considerable importance.

Although Russell considered that glaciers took immediate possession of the Yakutat region as it rose from the sea, Tarr, after a more thorough survey, considers "that there was profound denudation before the glaciers took possession of the region is indicated by the truncated folds and by the valley system in the peninsula, which is distinctly a system of mountain drainage lines, later occupied and profoundly deepened and broadened by ice".

Professor Tarr, after dealing in detail with all the main valleys, their glaciers, and the variable nature of their advances and retreats, as evidenced by the observations of previous explorers and the deposits they have left behind them, comes to the following conclusions:—

"Of all the hypotheses proposed, glacial erosion alone appears capable of explaining all the facts. It accounts for the broadened and greatly overdeepened main valleys, with truncated spurs, spurless walls, steepened slopes, and immature drainage lines; the U shape of the hanging tributary valleys; the non-progressive, irregular discordance in the hanging level of these; the difference in erosion from place to place; the irregularities of the valley bottoms and the through valleys—a combination of features which has never been described, except from a region which has been, or still is, occupied by glaciers.

"Against glacial erosion little has been urged further than the

[1] "The Yakutat Bay Region, Alaska: Physiography and Glacial Geology," by Ralph S. Tarr: United States Geological Survey, Professional Paper 64. 4to; pp. 184, 37 plates, 10 maps, and section. Washington, 1909.

argument that ice is not a powerful agent of erosion, and that it acts to protect rather than erode. This conclusion has been based largely on observations along the margins of weak dwindling valley glaciers.

"In the face of such evidence that ice *has* eroded, it is hardly demanded that one shall show that it really can erode. Nevertheless it may not be amiss to point out several facts bearing directly on the question. In the first place there was an enormous thickness of ice, supplied from many tributaries and without doubt flowing with comparative rapidity through the valleys. Second there is the direct evidence that ice was actually eroding. The *roche moutonnée* surfaces, the evidence of plucking, the polished, scratched, grooved, and fluted rock exposures in all parts of the inlet, and the extensive moraine deposits, all testify to the fact of erosion by the glaciers, and the existing glaciers add another evidence, namely, that of rock flour issuing from the ice fronts in the glacial streams.

"Whether one assumes that this erosion amounts to an inch in a year or an inch in a score of years, the fact of ice erosion must be accepted. One might see a small stream of clear water at the bottom of a deep gorge and say, correctly, that such a stream can not have formed so profound a gorge . . . But the flood stream, like the ice flood, is a different agent in degree."

It must be always remembered that all glaciated surfaces were last sculptured by the thin end of the retreating glacier which finished by polishing only. A finished statue frequently shows no signs of the rough work done by the chisel to commence with.

Between Russell Fiord and the Alsek River to the east the mountains rise to a height of four or five thousand feet. "The mountain slopes, where not too steep, are snow-covered, and all the valleys are deeply filled with streams of ice." "Such a condition of ice flood, drowning the valleys and rising high on the slopes of the mountains, which project as nunataks above the glaciers, is so different from that of the normal valley glacier that it seems to demand a special name; it is therefore proposed to apply to it the name 'through glacier'." In such a region the ice-flow will not always be from the divide. It will sometimes flow over a divide and cut a through valley like Russell Fiord itself.

Professor Tarr mentions an interesting case, which he saw, of a hanging valley glacier, more than a mile in length, slide bodily out of its valley; for this reason the valley was named Fallen Glacier Gulch.

It appears that the glaciers which enter the Russell Fiord are melted most rapidly at the surface of the sea. Below the water a snout of ice projects. Masses of this break off and rise to the surface. "Bergs immediately in front of the glacier are prevailingly either white, blue, or black in colour. The white bergs are derived from the ice walls above the sea; the blue ones, which are often a beautiful Antwerp blue, rise from below the water; the purely black icebergs, which are by no means uncommon, rise mainly from the base of the glacier, though a few fall from the debris-covered portions of the ice front." "In the warm summer air the blue icebergs quickly whiten." The sun breaks up the ice into its constituent granules, and the surface whitens owing to refraction and reflection from the granules.

Professor Tarr has made a most interesting contribution to glacial science. Only a few of the matters dealt with have been referred to, but the whole paper deserves careful perusal.

NOTICES OF MEMOIRS.

Relationship of Niagara River to the Glacial Period. Bulletin Geol. Soc. America, August 10, 1910, pp. 433–48.

IN this paper Dr. J. W. Spencer records further observations made by him on the Whirlpool – St. David's Valley, Gorge and Canyon. The buried canyon occurs at the south end of the Whirlpool, some 3 miles from the escarpment. Above this is a shallower and smaller channel 2 miles further south. Beyond the ridge is another ancient valley trending to the south, and deepening to 66 feet in 1½ miles at the site of the falls themselves. In this distance the valley broadens from less than one quarter to over a mile, descending gradually a more gentle gradient throughout a longer course than that of the Whirlpool–St. David's Gorge. The buried gorge leading from the Whirlpool is bounded by compact limestones with steep faces, except where rounded and glaciated with striations along the direction of its course. This ancient and now buried gorge increases from 1,400 feet at the Whirlpool to 1,800 feet in a distance of 2½ miles. Professor Spencer discovered in this gorge, at a depth of 186 feet, the remains of a buried interglacial forest. Interglacial beds were first recorded in Canada by Mr. D. F. H. Wilkins, at Port Rowan on Lake Erie, in 1878. A little lafer, at Scarbo' Heights, east of Toronto, they were recorded by Dr. George Jennings Hinde, F.R.S. (*Canadian Journal*, Toronto, vol. xv, p. 388, 1878). This was the foundation of interglacial geology in the Ontario basin.

In the neighbourhood of the Whirlpool Gorge the surface of the Niagara limestone floor has been planed off, polished, and grooved, the strongest striations being to south 60° west and weaker ones south 60° east; best seen at the quarry on the mountain-top east of St. David's, where the drift is reduced in places to only 4 feet. Several well-sections are described, one of which passed through 293 feet in depth of glacial and other detrital deposits. Everywhere beneath the neighbouring drift-deposits lie buried channels, and high above the Whirlpool Channel is an esker-like ridge of sand and gravel rising at one point to 442 feet above the lake.

In the borings in Whirlpool Channel have been discovered remains of a cool climate forest and soil, at a depth of 186 feet below the surface, with proof of three or four glacial formations since that time, like the Pleistocene Series at Toronto.

Before the forest bed, at least two glacial formations had been left in the buried channel, below which lie some 100 to 200 feet of still older glacial deposits. This lowest drift lies in a rock-bordered valley which had undergone a far greater amount of erosion than that during or since the Glacial period. From all the evidence Professor Spencer concludes therefore that this now filled trough is of pre-glacial origin. The age of the modern Niagara River is also found to be younger than

the glacial deposits about the western end of Lake Ontario, though not so recent as the later Wisconsin accumulations in other localities.

Before the birth of the falls the ice-sheet had receded beyond the greatest of all the moraines of Ontario, which lie between Lake Ontario and Lake Simcoe and between this lake and Georgian Bay, a distance of more than 120 miles north of Niagara Falls, so that the drainage of Lake Huron then passed down the Trent Valley. From the terrace north of Lake Nipissing the ice-sheet had receded 230 miles or more to the north of Niagara before the birth of the falls. But the Ottawa Valley farther down was still blocked. The Ontario Valley was open to at least near the eastern end of the lake, so that it permitted the flow from Algonquin Lake down the Trent Valley, although the ice was not removed from the St. Lawrence till some time after the birth of the falls. This was the last ice-sheet, and we only know that it disappeared so long ago that there was time for the excavation of the inner gorge of Niagara River, extending from Lake Ontario to a point inside the canyon of Niagara, since reflooded and drowned 180 feet by the subsequent north-eastward tilting of the region.

REVIEWS.

I.—A Text-Book of Geology. By Philip Lake, M.A., F.G.S., and R. H. Rastall, M.A., F.G.S. 8vo; pp. xvi, 494, with 32 plates and 134 text-illustrations. London: Edward Arnold, 1910. Price 16*s.* net.

THIS volume, issued as one of "Arnold's Geological Series" under the general editorship of Dr. Marr, is of larger dimensions than the series in course of publication on Economic Geology. As a text-book it will occupy an appropriate position between the *Geology for Beginners* of Professor Watts and the two-volume textbook of Sir Archibald Geikie. In the first part Mr. Rastall gives a clear and concise account of the principles of the science as illustrated by agents now at work; he describes rock-structures and earth-movements, and gives special petrological descriptions of the igneous rocks, of metamorphism, ore deposits, and mineral veins, occupying in all 279 pages. In the remaining portion, also admirably executed, Mr. Lake deals with the principles of stratigraphy, and with the fauna and flora of the great geological systems.

The book is well printed, admirably illustrated, and it has a good index; above all, it is written by two experienced workers and teachers, who have brought before us the latest results of geological research. Few references, however, are given to authorities.

The student will welcome the exposition of rock-structures, of folds, and the formation of overthrusts, the treatment of earth-sculpture and of the agents of denudation, attention being called to the dominant action of particular agents of weathering, transport, and corrosion under different climatic conditions and in different latitudes.

The development of rivers is explained in diagrammatic form, but the student has to bear in mind that the actual river-courses are liable

to almost endless modification, according to the structure of the ground, the nature of the rocks, the effects of subsequent uplift and adjustment, and the changes caused by the denudation of strata that conceal old topographical features. Attention is drawn to the variations of slope that arise in the course of a stream during the process of grading before it has reached the base-line of erosion. The term *thalweg* is said to be generally employed "to express the course of a stream considered in a vertical plane". By Mr. C. S. Slichter (Water-Supply Papers No. 67, U.S. Geol. Survey) the term is applied to the lowest line of drainage in a valley including not merely the surface flow but "the underground current, in general coincident with the thalweg", and the opinion is quoted "that the subterranean thalweg on the main line of underground drainage is usually nearer the steeper side of the valley than is the surface stream".

A good picture of the Sphinx illustrates the rounding and etching produced by wind-blown sand. Useful explanations are given of the words *dreikanter*, *zeugen*, etc., employed by some geologists, although the burdening of science with such technical terms, when 'facetted pebbles' and 'tabular outliers' should be sufficient, is somewhat pedantic and ill calculated to advance knowledge.

The pictorial plates have been well chosen, and they include many effective views of rock-structures, joints in igneous rock, strain-slip cleavage (from the Geological Survey), vertical strata, glaciers and glacial phenomena, natural arch and stacks, volcanoes and volcanic phenomena (including the 'spine' of Montagne Pelée), Tertiary basalt dyke, etc. The plates all illustrate Mr. Rastall's portion of the volume.

Mr. Lake commences with a philosophic essay on the principles of stratigraphy and on the methods of correlation. By means of instructive diagrams he shows the theoretical distribution in space and time of a species, from what would in old days have been termed a 'centre of creation'; but, as the author remarks, "many species had no definite beginning and no definite end, and their vertical ranges accordingly are also ill-defined." Species with a wide range were usually held to have a corresponding duration of time, but this does not apply to all forms, and those of zonal value "must belong to a group in which evolution is proceeding rapidly".

From the Pre-Cambrian or Archæan, in upward succession, the author describes the main characters and subdivisions of the great geological systems, and with the aid of maps points out their distribution in the British Isles. The more important facts are clearly laid before the reader without much detail; thicknesses of strata and economic products are not dealt with, unless incidentally. The fauna and physical conditions, the characteristic fossils and zones of the different formations, are the chief subjects.

The Devonian Series of North Devon and West Somerset is illustrated by Etheridge's map of 1867—essentially a diagram—and, as Mr. Lake admits, so far as our present knowledge goes, there is definite palæontological evidence that the Morte Slates are Lower Devonian.

We are glad to observe that the author has been bold enough to

adopt the more widely accepted and common-sense Ammonite zones in the Jurassic and Cretaceous systems, and in consequence we read of the zones of *Ammonites Parkinsoni*, *A. perarmatus*, *A. varians*, etc., instead of being bewildered by a succession of new generic names, which vary to some extent in every textbook. The same plan was wisely adopted by Mr. H. Woods in 1907 in his Catalogue of the Fossils in the students' stratigraphical series at the Sedgwick Museum. Moreover, we are glad to note the rightful application of the term Bathonian to the Great Oolite Series, and that of Bajocian to the Inferior Oolite Series.

In dealing with the Pliocene Series the subject is illustrated by Mr. Harmer's map of the successive stages of the Crag divisions; and in reference to the Pleistocene Series the map of S. V. Wood, jun., showing the distribution of the Boulder-clays of the East of England, is inserted. To this map Mr. Harmer has added arrows to indicate the flow of the ice-sheets. This is the more important as Mr. Lake himself has adopted a somewhat negative attitude with regard to the origin of Boulder-clay in general. The subject is, however, treated very briefly, and the same may be said of the Post-Glacial Series, Palæolithic and Neolithic times being dealt with in a couple of pages.

In a final chapter Mr. Lake gives a useful summary of the great physical changes that have characterized the geological history of the British Isles.

II.—The Geology of Building Stones. By J. Allen Howe, B.Sc., F.G.S. 8vo; pp. viii, 455, with 8 plates, 7 maps, and 31 text-illustrations. London: Edward Arnold, 1910. Price 7*s.* 6*d.* net.

THIS is the fourth volume in "Arnold's Geological Series", edited by Dr. J. E. Marr, works on Coal and Coal Mining, Ore Deposits, and Water Supply having already been published. A comprehensive book on building-stones has long been wanted, as in this country since 1872, when Professor Hull's volume on *Building and Ornamental Stones* was published, we have had to depend mainly on the more or less scattered geological information given in sundry Geological Survey Memoirs, on the work of D. C. Davies on Slate, on that of G. F. Harris on Granites, and on the four excellent chapters in Dr. J. V. Elsden's *Applied Geology*, pt. ii, 1899.

Before settling down to the severer portions of his work, Mr. Howe gives a pleasant sketch of the influence of geology on the characters of the buildings in Britain, and on the aims and limitations of his work. Ornamental stones are dealt with but incidentally, as in references to Napoleonite, Luxullianite, the Norwegian 'Pearl' (augite-syenite), and various kinds of marble which, as in the case of the Devonshire limestones, are largely used for building purposes.

After contributing a useful chapter on minerals, the author takes up the subject of rocks, dealing first with the various granites and greenstones, then with sandstones, grits, conglomerates, and breccias, and their cementing materials, with limestones (calcareous and magnesian), with slates and stone-tiles, and with sundry miscellaneous

building materials, such as flint and artificial stone. Then follow important chapters on the decay, preservation, and testing of building-stones, appendices on quarries, a list of some useful books, and an excellent index.

While the bulk of the work is rightly taken up with descriptions of British building-stones, their lithological characters, chemical and physical properties and distribution, there are also descriptions of the leading rocks used for building purposes in various parts of the world. The general distribution of the rocks in Britain is shown on the series of maps, and the structure of many of them is well depicted on plates from photomicrographs. The illustration of the weathering of Portland Stone is also excellent. Attention is given to the adaption of particular rocks to different purposes and in diverse situations, and mention is made of buildings constructed of the more important freestones and other materials. A little more might have been said with advantage about quarry-water and the seasoning of stone, and of the use of the term freestone.

A few statements and some names of places require emendation; thus the Clipsham Stone (p. 218) comes from Rutlandshire (not Oxfordshire), as may be inferred from previous references to it, while the Taynton Stone (p. 238) was quarried near Burford in Oxfordshire, though not far from the borders of Gloucestershire. The reference on p. 429 should be to Taunton.

The author has evidently devoted great pains to render his work as complete as possible, although the limitations of space have unfortunately prevented references to particular sources of information; but he has demonstrated by his careful record of facts and by his lucid explanations how much of scientific and practical interest, as well as importance, may be learnt from the geological study of building-stones.

III.—The Geology of the Country around Nottingham. By G. W. Lamplugh, F.R.S., and W. Gibson, D.Sc. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, Adelphi Terrace. 8vo; pp. vi. 72, with 6 photographic plates, 1 sheet of sections, and 9 text-illustrations. 1910. Price 2*s*. Special colour-printed map, price 1*s*. 6*d*.

FOR the benefit of students in important educational centres the Geological Survey has issued special maps when the town or city happened to come near the margin of the ordinary (New Series) 1 inch sheets. London (as noted in our December Number) required four sheets. Oxford, and now Nottingham, have been given special sheets, while places like Cardiff, Swansea, and Southampton come within the central portions of the ordinary sheets. Among the New Series sheets Plymouth might advantageously be represented on a special sheet.

The memoir before us is made up of Sheets 125, 126, 141, and 142, already described in four memoirs, but the object now is to give a more general account of the geology, with less detail. It is rather curious to note that the usual chapter on economic geology is omitted, because "the map and present memoir are intended primarily to serve the

requirements of Nottingham as an educational centre"; but would not most of the students who take up geology as a serious pursuit probably do so with the view of gaining their livelihood as mining engineers, geological surveyors, or teachers, and require some knowledge of the applications of geology? As pointed out, they will have the opportunity of purchasing the four memoirs already mentioned, and in the present work they may gather information about the structure of the coal-field, the sequence of the coals, and the organic remains which mark horizons. References are also given to the moulding-sands in the Bunter and to the gypsum in the Keuper, as well as to brick-clays.

As an exposition of the main geological features, of the palæontology and physical history of the formations, the work is excellent; and the illustrations of the Trent Valley at Nottingham during the flood of 1875, of the Magnesian Limestone Series near Kimberley, and of the Crags of Nottingham Castle, are particularly good.

The formations included in the area extend from the Millstone Grit to the Lower Lias, with Glacial Drift, River Gravels, and Alluvium. Attention is finally directed to subjects on which further information is needed, and to these the student, bent on research, may profitably devote his spare time. It is noteworthy that no palæolithic implements have been obtained in the district.

IV.—The Geology of the Country around Alresford. By H. J. Osborne White, F.G.S. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, Adelphi Terrace. 8vo; pp. iv, 102, with 15 text-illustrations. 1910. Price 2*s*.

WE welcome another memoir by Mr. Osborne White, the previous one on the Geology of Basingstoke having been noticed in the Geological Magazine for February, 1910. As before, the author, while adding considerably to our knowledge, has dealt carefully and generously in the text with the work of other observers, and of these Gilbert White will ever be most intimately associated with the district.

The area which is included in Sheet 300 of the colour-printed Geological Survey map lies directly south of that of Basingstoke, and Alresford is situated a little to the west of the central portion.

The formations that appear at the surface extend from the Weald Clay to the Reading Beds, and comprise sundry superficial deposits. There are no deep borings to indicate how far westwards the Lower Cretaceous strata may extend. The Weald Clay appears in a portion of Sussex, in the south-eastern corner of the area; thence westwards, as shown in the longitudinal section on the map, we cross the bold hills of Lower Greensand, the Gault vale, the gentle scarp of Upper Greensand, and the Chalk escarpment. While the name Selbornian was appropriately taken as a chronological division for the Upper Greensand and Gault, the map shows the importance of separating the two formations.

The author gives detailed accounts of all the subdivisions, of their fossils and economic products. In the Lower Greensand the Bargate Beds occur in the upper part of the Hythe Beds, below the Sandgate

Beds, although near Godalming and Guildford, where that clayey division is not recognized, the Bargate Beds have been grouped by some geologists with the Folkestone Beds.

The palæontological zones in Gault and Upper Greensand are dealt with as fully as possible, the zone of *Hoplites lautus* not being distinguished from that of *H. interruptus*, and that of *Peeten asper* not being clearly established. The Chalk zones are fully represented up to that of *Actinocamax quadratus*, and there is a good tabular list of all the fossils.

Only one outlier of Reading Beds has been observed near East Stratton, and there an imperfect section shows about 10 feet of sand and loam, with pebbly basement-bed and a covering of Clay-with-flints.

Greywethers occur in various places, some pebbly, and the author remarks that "There appears to be no good grounds for referring any of the local sarsens to the Reading Beds". On the other hand, it may be said that there are no good grounds for not regarding them as derived from that formation.

The author has given careful attention to the tectonic structure and the system of gentle folds, the principal and minor anticlines and synclines being shown on a sketch-map. These have influenced the topography indirectly, and their relation to the various streams and rivers is briefly discussed.

With regard to the Clay-with-flints the author observes that while it is largely made up of debris of Reading Beds, "it rests indifferently on surfaces which may be four or five feet, or four or five hundred feet, below the Eocene basal plane," and "may be said to be in process of formation at the present day" under the solvent action of rain. He agrees with Mr. Jukes-Browne "that much of this deposit, in its present form, is a result of vigorous soil-cap movement, occurring under sub-arctic conditions, during late Pliocene and early Pleistocene times".

Three small patches of stony sand and loam 370 to 390 feet above Ordnance Datum occur on the Gault in the north-eastern part of the area; and these, the only representatives of 'Plateau Gravel', in the opinion of the author "may be correlated with the Palæolithic deposits of Farnham Common", further to the north-east.

The River Gravel, Rain-wash, and Alluvium are described, and there is an interesting chapter on Economic Geology. Remarks are made on the soils and land dressing, there being a marked connexion between the soil and subsoils, and the agricultural features. Building and road materials, springs and water-supply also receive attention.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *December* 21, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Keuper Marls around Charnwood Forest." By Thomas Owen Bosworth, B.A., B.Sc., F.G.S.

The area under consideration comprises some 300 square miles,

including the towns of Leicester, Loughborough, Coalville, and Hinckley. As has been shown by Professor Watts, the Charnian rocks project through a mantle of Triassic deposits which once completely covered them. In numerous quarry-sections the relation of the Keuper to the pre-Cambrian rocks is well exposed.

The quarries generally have been opened in the summits of the more or less completely buried hills. A quarry is so worked that its outline follows the contour of the buried hill; consequently, the section presents but a dwarfed impression of the irregularity of the rock-surface. Nevertheless, considerable undulations are observed, and wherever there are any sections at right angles to the contours, the rock-slopes are seen to be remarkably steep. Contoured maps have been prepared, showing the features of some of these covered peaks.

On the buried slopes and in the gullies are screes and breccias, and bands of stones and grit are present in the adjacent beds of marl. All these stones, in every case, are derived only from the rock immediately at hand. They never resemble pebbles, but often are fretted into irregular shapes. Where exposed to the present climate, the Charnian igneous rocks are deeply weathered and disintegrated. But the same rocks beneath the Keuper are fresh right up to the top, as also are the rock-fragments in the marls.

The Keuper marls lie in a catenary manner across the gullies, and probably across the large valleys also, for they dip away steeply in all directions around each buried peak.

There has been almost no post-Triassic movement in Charnwood. Nevertheless, the beds must have been originally laid down horizontally, for they are in no way peculiar, and contain the normal seams of shallow-water sediment. All the points of contact of any one bed with the Charnian rocks lie on one horizontal plane. The inclination of the strata must, therefore, be due to subsequent sagging.

The Upper Keuper deposits accumulated in a desert basin, of which parts were dry and parts were occupied by ever-shifting salt lakes and pools. In these waters the red marls were laid down. The red marls are of several different types, and are usually well-bedded. The principal ingredients are a certain aluminous mineral in very small particles and a much smaller proportion of very fine quartz-sand. There is generally 20 or 30 per cent. of dolomite present, in the form of minute rhombs.

The grey bands include various kinds of rock. Each band usually contains one or more seams of well-bedded sandstone or quartzose dolomite, and may safely be relied upon to indicate the bedding. The irregularities are due to irregularity in the bleaching above and below these porous seams.

The abundant heavy minerals are garnet, zircon, tourmaline, staurolite, rutile, magnetite. These are found in every sediment—marls, sandstones, grits, breccias, etc. The grains are intensely worn.

The quartz-grains are sometimes evidently wind-worn. The sand in the grey bands is coarser and more abundant than that in the red marls. Each grey band marks the introduction of coarser sediment into the basin. The false bedding is mainly from the south-west.

The bands are of wide extent and are due to inflows of fresh water from the surrounding hills, which from time to time spread themselves far and wide over the dry portions of the desert, and were often completely desiccated before reaching any pre-existing pool. Where these waters evaporated the quartzose-dolomite seams were formed, bearing ripple-marks and salt-pseudomorphs. The ripples indicate prevalent south-westerly winds.

2. "The Relationship of the Permian to the Trias in Nottinghamshire."[1] By Robert Lionel Sherlock, B.Sc., A.R.C.Sc., F.G.S.

In South Northamptonshire the Permo-Trias consists of the following divisions:—

Keuper . . .	Marls. Waterstones.
Bunter . . .	Pebble Beds. Lower Mottled Sandstone.
Permian . . .	Middle Marl. Lower Magnesian Limestone. Marl Slates and Breccia locally.

The conformability or unconformability of the Bunter to the Permian has been much discussed, but it is generally considered that there is a small unconformity between them. The evidence for this is the appearance of an Upper Magnesian Limestone, and locally an Upper Marl, between the Middle Marl and the Bunter, as the beds are followed northwards, so that the Bunter appears to overlap the Permian divisions from north to south.

In this paper a section on the Great Central Railway, near Annesley, is described, which shows a gradual passage from the Middle Marl into the Lower Mottled Sandstone. Detailed mapping on the 6 inch scale between Nottingham and Market Warsop has confirmed this conclusion.

From Nottingham to Mansfield the Middle Marl retains a uniform character and thickness, but at Mansfield it is apparently absent, and the Bunter has been thought to overlap it and rest directly on the Lower Magnesian Limestone. At the same place the limestone becomes very sandy, forming the Mansfield Sandstone. It is shown that these two phenomena can be best explained by supposing that a river deposited a sand-bar at Mansfield during Permian times, so that the limestone was replaced by sandstone, as was also, later, the Middle Marl. The sandy representative of the Middle Marl has been mistaken for Bunter, and so given rise to the appearance of an overlap.

North of Mansfield the Middle Marl becomes normal again. Near Cuckney the Upper Magnesian Limestone first appears as a very thin bed, and evidence is brought forward to show that the limestone arises as thin lenticular bands in the Passage Bed, which develop northwards into a definite bed. In precisely the same way sandstone lenticles in the marl in South Nottinghamshire develop into a definite bed of sand-rock, called the Lower Mottled Sandstone. At first a thin Upper Magnesian Limestone is found below a diminished representative of

[1] Communicated by permission of the Director of H.M. Geological Survey.

the Lower Mottled Sandstone; but, on following the outcrop northwards, the Upper Limestone is seen to grow in importance and the Lower Mottled to diminish, until, in South Yorkshire, it is not found.

The Permian rocks continue to increase in thickness and the Bunter to diminish, until the Pebble Beds also become unrecognizable, in North Yorkshire. Also the Middle Marl now fails, and a thick mass of limestone remains to represent the Permian. The Keuper Waterstones persist throughout, and seem to be slightly unconformable to the Bunter.

From these considerations it is believed that the Upper Magnesian Limestone and Upper Marl of the northern part of the outcrop are the time equivalents of the Bunter of South Nottinghamshire, the one being deposited in an inland sea, comparable with the Caspian, the other along the coastline, which was slowly moving northwards.

The palæontology of the Upper Magnesian Limestone is discussed, and the evidence derivable from the fossils is shown to be not unfavourable to the above view.

2. *January* 11, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Zonal Classification of the Salopian Rocks of Cautley and Ravenstonedale." By Miss G. R. Watney and Miss E. G. Welch. (Communicated by J. E. Marr, Sc.D., F.R.S., F.G.S.)

The district described lies north-east of Sedbergh and west of the Dent Fault. An account of the literature treating of previous work is given, and the succession of the zones is described. They are as follows:—

Lower Ludlow.	D 3.	Zone of *Monograptus leintwardinensis.*
	D 2.	,, *M. nilssoni.*
	D 1.	,, *Phacops obtusicaudatus.*
Wenlock.	C 4.	,, *Cyrtograptus lundgreni.*
	C 3.	,, *C. rigidus.*
	C 2.	,, *Monograptus riccartonensis.*
	C 1.	,, *Cyrtograptus murchisoni.*

Below are Valentian rocks (A and B divisions of the Stockdale Shales).

The Wenlock Beds are most fully developed in some streams entering the River Rawthey from the south. The detailed succession of these is given, and confirmatory sections are described in other parts of the district.

The Ludlow Beds are found mainly in the northern part of the area, where the geology is simpler.

A comparison is instituted between these beds and those described in the Welsh Borderland by Miss Elles & Miss Wood (Mrs. Shakespear), and those of Wenlock age in Southern Sweden described by Tullberg.

Cautley.	Welsh Borders.	Southern Sweden.
Zone of *Monograptus leintwardinensis.*	Zone of *M. leintwardinensis.*	
Red grits and flags, ? =	,, *M. tumescens.* ,, *M. scanicus.*	
Zone of *Monograptus nilssoni.*	,, *M. nilssoni.*	
,, *Phacops obtusicaudatus*, ? =	,, *M. vulgaris.*	
,, *Cyrtograptus lundgreni.*	,, *C. lundgreni.*	Zone of *C. carruthersi.*
,, *C. rigidus.*	,, *C. rigidus.* ,, *C. linnarssoni.* ,, *C. symmetricus.*	,, *C. rigidus.*
,, *Monograptus riccartonensis.*	,, *M. riccartonensis.*	,, *M. riccartonensis.*
,, *Cyrtograptus murchisoni.*	,, *C. murchisoni.*	,, *C. murchisoni.*

A description of a *Cyrtograptus* intermediate in character between *C. rigidus* and *C. symmetricus*, and of a new *Monograptus* from the *Nilssoni* Beds of Wandale Hill, is given in a palæontological section.

2. "On a Collection of Insect-Remains from the South Wales Coalfield." By Herbert Bolton, F.R.S.E., F.G.S., Curator of the Bristol Natural History Museum.

The author describes nine examples of insect-remains, all being, with one exception, blattoid in character. Seven are described as new species. Six of the specimens were obtained from the horizon of the Mynyddislwyn Vein and Swansea Four-Foot Seam; two from shales associated with the Graigola Seam, and a 22 inch seam occurring 40 yards below it; while one specimen was found in shales associated with the Rhondda No. 2 Seam, and therefore on the same horizon as the example of *Etoblattina* (*Archimylacris*) *woodwardi*, Bolton, previously described by the author in the Geological Magazine for 1910, p. 147.

The whole of the insect-remains are referable to three horizons—one at the base of the Upper Series of the Coal-measures, and two in the upper part of the Pennant Series. Two indeterminate species are referred to the genus *Archimylacris*, two to *Hemimylacris*, one to *Archimylacris* (*Schizoblatta*), one to *Archimylacris* (*Etoblattina*), one to *Gerablattina* (*Aphthoroblattina*), one to *Orthomylacris*, and one to *Lamproptilia*. The last-named genus is new to the British

Coal-measures. Attention is drawn to the association of the blattoid remains with *Cordaites* leaves bearing the impressions of the tests of *Spirorbis pusillus*. The suggestion is put forward that possibly Carboniferous cockroaches were not only phytophagous in habit, but frequented decaying *Cordaites* leaves in order to feed upon the *Spirorbis*.

The presence of Archimylacrid and Orthomylacrid forms, no less than the presence of a species of *Lamproptilia*, is considered indicative of a considerable advance in insect development in the British Carboniferous beyond the more primitive palæodictyopteran types; while their abundance in the Pennant and Upper Series of the South Wales Coal-field may justify the hope of finding more primitive forms at a lower horizon in the same coal-field. Their occurrence may also be indicative of the remains of a terrestrial fauna somewhere in the South Wales Coal-measures.

The President announced that at 7 p.m. on Wednesday, January 25, 1911, a Special General Meeting would be held, in order to consider the following Resolutions of Council:—

(*a*) That the space now occupied by the Museum be made available for the extension of the Library.

(*b*) That it is desirable that the Society's collections of Fossils, Minerals, and Rocks, with certain exceptions to be subsequently specified, be offered to one or more of the National Museums, provided that guarantees be obtained that the specimens will be properly registered and rendered available for scientific purposes.

(*c*) That it is not desirable that the Society should accept money for any part of the collections, or in consideration of them.

(*d*) That the Council be empowered to approach such Institution or Institutions with a view to carrying the above resolutions into effect, and that the Council shall call another Special General Meeting to express approval or otherwise of the arrangement proposed.

II.—Edinburgh Geological Society.

December 21, 1910.—Dr. Horne, F.R.S., in the Chair.

The following paper was read:—

"The Carboniferous Rocks and Fossils in the Neighbourhood of Pitscottie, Fifeshire." By R. M. Craig, M.A., B.Sc., Assistant in the Geological Department, The University, St. Andrews, and David Balsillie, Student of Science, The University, St. Andrews.

The authors described a section of Carboniferous strata exposed in Kininmonth Den, near Pitscottie, Fifeshire. These consist of sandstones, shales, and limestones, some of which are richly fossiliferous. The most striking feature is the occurrence of well-marked bands of limestone charged with true marine fossils, comprising corals, brachiopods, polyzoa, and lamellibranchs, which elsewhere are characteristic of the Lower Limestone group of the Carboniferous Limestone Series. On physical and palæontological grounds, the authors suggest that the beds in this stream section ought to be grouped with these lower limestones rather than with the Calciferous Sandstone Series as mapped by the Geological Survey. The authors showed a suite of fossils in illustration of the paper.

CORRESPONDENCE.

HIGH-LEVEL SHELLY DRIFT.

SIR,—Mr. Crook (GEOL. MAG., January, 1911) is wrong in supposing that the upholders of the land-ice hypothesis for the origin of our high-level shelly drifts are satisfied by the rendering of their views as usually stated by the opponents of the hypothesis, and he credits them undeservedly with docility in the matter. As only one of the upholders in question I venture to refer Mr. Crook to a letter of mine in *Nature* for May 6, 1897 (vol. lvi, p. 10), which displays a really deplorable lack of docility. Since that was written I have repeatedly set forth the full argument, in a more subdued tone, in applying the hypothesis to specific instances—e.g., in memoirs on the Isle of Man, on the Dublin district, on the Belfast district, and in an address to Section C of the British Association, York, 1906—referring in the last, among other instances, to observations in North Greenland even more illustrative than that to which Mr. Crook draws attention. Finally, last summer, in Spitzbergen, I saw for myself some remarkable examples of the entanglement and uplift of marine detritus by glaciers and its incorporation with the morainic products of land-ice.

It has been persistently explained that our *high-level* shelly drifts are believed to represent, not a bodily transportation of their material *en masse*, but an uplifting and scattering of the marine detritus piecemeal by the advancing ice-sheets. Statement of the case has of late grown wearisome even to its upholders by unavailing reiteration, and the misapprehension which has impressed Mr. Crook will no doubt continue to reveal itself from time to time as blandly as ever.

G. W. LAMPLUGH.

ST. ALBANS.
January 7, 1911.

MISNAMED LOCALITIES AND THE *UINTACRINUS* CHALK AT KESTON.

SIR,—In September last you kindly published a letter from me respecting the discovery of the Marsupite zone at Farnborough in Kent. By some accident this appeared as *Marsupites* in Surrey, which zone had been worked by Mr. George Young, F.G.S., and described by him in the Proceedings of the Geologists' Association. I did not see the letter for a long time after its publication, or should have written at once to correct the error.

In October last, while examining the chalk by the roadside immediately opposite Keston Church, where about 18 inches of it are revealed above the footpath, I discovered ample proof of the presence of the *Uintacrinus*-zone, which I had previously discovered at Orpington, Fox Hill, and West Wickham. The great point of interest attached to this is that the fauna revealed in the Leave's Green Pit a few yards south of Keston Church is that of the

Micraster cor-anguinum-zone, and, as I have stated elsewhere, is identical with the Northfleet, Gravesend, Dartford, Farningham Road, and Foot's Cray Chalk, so that we now know that the topmost beds of this zone mark the whole of this area, the *Uintacrinus* and Marsupite zones having been denuded.

While dealing with this subject it may not be inappropriate to give some information respecting the fossils in the British Museum and elsewhere labelled "Bromley" as regards locality. For many years I tried to solve this mystery, not being aware of any outcrop of Chalk in that district. My friend Mr. Watson, of the Catford Natural History Society, has kindly sent me the following:—*History of Chislehurst*, by E. A. Webb, p. 338: "From these now disused chalk-pits along the base of Camden Hill large numbers of fossils have been obtained from time to time. The locality, however, has generally been quoted as Bromley. There is a magnificent series of Echinoderms from this parish in the Natural History Museum, South Kensington, several of the examples being 'types'."

The pits are situated at the back of Willett's Mews; there is a drawing of them by Mr. Whitaker in his *Geology of London*, vol. i. The ecclesiastical boundary of Bromley may extend to this pit, hence the confusion which has arisen. The Mews is situated immediately at the bottom of the hill on turning to the left after leaving the 'down side' of Chislehurst Station.

G. E. Dibley.

Sydenham, S.E.
January 16, 1911.

MISCELLANEOUS.

Geological Survey of India.—Sir Henry Holland, K.C.I.E., F.A.S., came home on furlough from India in the autumn of 1909, leaving his colleague, Mr. T. H. D. La Touche, F.G.S., for the time in charge as acting Director. Both gentlemen having now retired from the Indian Service, Mr. Henry Hubert Hayden, B.A., B.E., F.G.S., has been appointed to succeed to the post of Director of the Geological Survey of India. Mr. Hayden joined the Department on January 3, 1895, and has seen service in most parts of India and Burma. He is, however, best known for his survey of Spiti in the Central Himalayas of the Punjab, and for his work on Eastern Tibet. Since the publication of these two important memoirs he has spent some time in Afghanistan, the results of his work being now practically ready for publication.

Two Assistants have been recently appointed to complete the Staff of the Indian Survey; namely, Mr. H. S. Bion, B.Sc., who has been an Assistant to Professor E. J. Garwood at University College, London; and Mr. C. S. Fox, B.Sc., Lecturer on Mine Surveying in the Birmingham University.